JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

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THE Franklin Institute is not responsible for the statements and opinions advanced by contributors to the *Journal.*

The Franklin Institute.

THE ENDOWMENT FUND.

The accompanying circular-letter, issued by the Committee on Endowment, with the approval of the Board of Managers, and sent to all members, fully explains the aim and expectations of the Committee.

It is the earnest wish and hope of the Committee that all the members should participate in this movement to relieve the pressing financial needs of the Institute. Accordingly, the Committee trusts that

members will not hesitate to subscribe at once for whatever amount they may feel disposed—no matter how small.

The growth of the various departments of the Institute by natural accretion, and the pressing demands for the extension of its work in various directions, have, during the past decade, increased the costs for maintenance and administration, and have been the cause of a deficit in nearly every year, notwithstanding the most careful husbanding of its resources.

It is of the utmost importance for the future prosperity and progress of the Institute, that a substantial addition to its annual revenues be acquired, not only to provide income sufficient to carry on its present work, but also to enable it to extend this in other directions; and it is the earnest desire and hope of the Board that the membership of the Institute generally will make a prompt and generous response to the appeal of the Committee on Endowment. W.

AN APPEAL FOR THE ENDOWMENT FUND.

PHILADELPHIA, October 1, 1898.

The Franklin Institute of the State of Pennsylvania, founded in 1824, is known to every citizen of Philadelphia interested in technical and scientific work, and it is proposed, in the near future, to still further expand the work of the Institute.

The Managers of the Institute are making an earnest effort to raise an endowment fund, and a Committee has been formed to bring before the members and friends of this world-famous society, its needs and requirements, to enable it to preserve the reputation it has brought the City of Philadelphia, and to continue the assistance given to its industries of every nature, as a fitting commemoration of its 75th anniversary, which will occur February 5, 1899.

The Managers are compelled to ask this aid by reason of the increase in necessary expenses, which now exceed the net revenue. The present endowment is small, and although the membership of nearly 2,000 contributes an annual addition to the income, this is not sufficient to carry on the work. The membership is composed largely of artisans, and the dues ($8.00 per year) are properly low, so that the benefits of the Institute may reach as many as possible.

One of the most complete scientific libraries in the world is now housed in a building which is not fire-proof (although a portion of it has been recently made as nearly so as possible under existing conditions), and the funds available are insufficient to properly maintain and increase it.

A fund of $350,000 is deemed requisite to adequately provide the income which could advantageously be used, and it is hoped that the present effort will speedily provide at least $100,000 of this amount.

The undersigned Committee confidently appeals to the citizens of Philadelphia for subscriptions to ensure the future great usefulness of the Institute, assured that the income from such a fund, devoted to its laudable purposes, will redound to the honor and credit of our city, and assist present and coming generations.

The Committee will be pleased to furnish any further information desired.

Subscription blanks may be obtained from the members of the Committee, or from the Actuary, at the Hall of the Institute, No. 15 South Seventh Street.

Very respectfully,

HENRY C. BROLASKY,
JOHN H. CONVERSE,
GEORGE V. CRESSON,
STEPHEN GREENE,
ALFRED C. HARRISON,
HERBERT M. HOWE, M.D.,
ALEXANDER KRUMBAHAR,
FRANK H. ROSENGARTEN,
JOSEPH M. WILSON, C.E.,
OTTO C. WOLF,

C. HARTMAN KUHN, *Chairman*,
Committee on Endowment.

Mining and Metallurgical Section.

Stated Meeting, March 9, 1898.

HISTORY OF THE PORTLAND CEMENT INDUSTRY IN THE UNITED STATES.

By Mr. Robert W. Lesley,
Associate Am. Soc. C.E.

To the general public, cement is usually associated with the numerous works of the Romans, but, in point of fact, the mortars used in the Roman construction were not of cement at all, but were mixtures of slaked lime and pozzolana, a volcanic dust which was found in large quantities in Italy. It was not until the end of the last century that the true principles of hydraulic cement were discovered by Smeaton, who, in the construction of the Eddystone Light-House, made a number of experiments with the English limestones, and laid down, as a result, the principle that a limestone yielding from 15 to 25 per cent. of residue when dissolved in hydrochloric acid will set under water. These limestones he denominated hydraulic limestones, and from the principle so laid down by him come the two great definitions of what we now know as cement, namely, the natural and artificial cements of commerce.

The first class of cement, the natural, such as the Rosendale, Lehigh and Cumberland cements, was first made by Joseph Parker in 1796, who discovered what he called "Roman cement," based upon the calcination at low temperatures of the nodules found in the septaria geological formation in England. This was practically the first cement of commerce, and gave excellent results. Subsequent to the discoveries by Smeaton, General Sir William Paisley went into an exhaustive series of chemical and other tests to determine how artificial cements could be produced which would correspond to the higher grades of hydraulic limestones described by Smeaton and the Roman cement which

was then commanding the market. Contemporaneous with him and working in the same scientific field was Vicat, a French engineer, who conducted investigations of the same general character, and, in his book on hydraulic limestones and cements, describes his many experiments which led to the scientific development of a Portland cement artificially made by calcining mixtures of chalk and clays at high temperatures to incipient vitrefaction.

While these experiments were going on, Joseph Aspdin, a bricklayer or plasterer, took out a patent in England in 1824 on a high grade artificial cement, and, at great personal deprivation, succeeded in manufacturing it on a commercial scale by combining English chalks with clay from the river beds, drying the mixed paste, and after calcining at high heat the material thus produced, grinding it to powder. This cement, which was the first Portland cement in the market, obtained its name from its resemblance when it became stone to the celebrated Portland stone, one of the leading building materials in England.

The growth of the natural or Roman cement industry in England was more rapid than that of the Portland cement and in the early days of Portland cement that article was sold at prices considerably lower than those of the Roman cement manufactured by Parker and his successors in the business. It was not until many years after Smeaton's discovery that there was much growth in the Portland cement industry. A few works were started in England and a few more were started on the Continent by friends or relatives of Aspdin, but the demand was very slight, and there was a doubt in the minds of engineers as to the character of the material. Along in 1850, when the question of building the London drainage works came up, John Grant, the engineer, decided to use Portland cement in its construction, and his two papers, published by the Institute of Civil Engineers, form the first scientific literature on the subject of cement testing, and were the first to put Portland cement to the front as a material upon which engineers could rely to the fullest extent.

In this country we make the natural cements similar to

the Roman cement of Parker, and also the Portland cement of Aspdin. The laminated cement rock of the Lehigh region from which, among others, natural cement is made, is calcined in open kilns, like lime kilns, a moderate heat only being used. The product is then ground, put into barrels, and is ready for shipment.

The rocks used in the manufacture of Portland cement are very similar to those from which natural cement is made. The various layers in the natural rock may vary in size or stratification, so that the lime, alumina and silica may not be in position to combine under heat, or there may be too much of one ingredient, or not enough of the others in close proximity to each other. In making Portland cement these rocks, properly proportioned, are accordingly ground to an impalpable powder, the natural rock being broken down and the laminæ distributed in many small grains. This powder is then mixed with water, and is made into a new stone in the shape of the brick, or block, in which all the small grains formerly composing the laminæ of the original rock, are distributed and brought into a close mechanical juxtaposition to each other. The new rock thus made is put into kilns with layers of coke, and is then calcined at temperatures from 1,600° to 1,800°. The clinker, as it comes from the kiln, is then crushed and ground to an impalpable powder, which is the Portland cement of commerce. Portland cement may be made from other materials, such as chalk and clay, limestone and clay, cement rock and limestone and marls and clays. In every case the principle is the same, the breaking down and the redistributing of the materials so that the fine particles may be in close mechanical union when subjected to the heat of the kiln.

The first branch of the industry to develop in this country was that of natural cement, and its inception was largely because "necessity is the mother of invention." The first large public works built in this country were the canals, and the most necessary thing to build a canal was mortar that would hold the stones together at the locks, or walls, under water. Consequently, wherever canals were to be built, there was a search for cement rocks, and all the earliest works in this

country were established on the lines of canals. Thus, on the Chesapeake and Ohio Canal are the Cumberland and Round Top Works; on the Lehigh Canal the works at Siegfrieds and Coplay, Pa.; on the Richmond and Allegheny Canal, the works at Balcony Falls, Va.; on the Delaware and Hudson Canal the large group of works at Rosendale and Kingston; and on the Falls of the Ohio Canal, the large aggregation of works about Louisville. From this same fact grew the early package used in shipping cement in this country, the barrel, which was the package best adapted to water transportation, and it took many years, even since the railroads came, to overcome the prejudice for this form of package and to substitute the paper or duck bag for the barrel.

The growth of the natural cement industry has been very rapid, having increased from 3,000,000 barrels in 1882, to about 8,500,000 barrels in 1896. The first Portland cement made here involved a great cost of labor, and could not be offered at prices very much below the foreign article, and, as the Portland cement in a building costing $1,000,000 to $1,500,000 represented only a small percentage of the total cost, and as the difference between the American and the foreign article represented only a small percentage of this amount, it was almost impossible to convince engineers and architects that American Portland cement should be used. It is an interesting fact that among the first great works to use American Portland cement were the jetties built by Capt. James B. Eads, and among the first buildings in which American Portland cement was used was the Drexel Building, Philadelphia. By slow degrees, however, the prejudice in favor of the imported Portland was overcome and the American industry showed its right to exist.

The first American Portland cement plant was that of the Coplay Cement Company, of which Mr. David O. Saylor, of Allentown, was the President. This plant was established about 1865, and made natural cement of excellent quality. Mr. Saylor, who was a man of indomitable energy and great ability, made up his mind in the early seventies that he could make Portland cement in this country, and his first

experiments are most interesting. He knew that by burning to incipient vitrifaction the rocks of his quarry he could make a cement that at short periods showed tensile strains equal to the imported Portland, but he found this cement would crumble away as time went on, owing to the variation in the raw material. By sheer force of his native ability, Mr. Saylor studied out and successfully applied to the Lehigh rocks the principle above mentioned as governing the production of Portland cement, though he was dealing with a material never before used for the purpose. The process was that which I have just described, and is still in use in some of the largest works in the Lehigh district. Mr. Saylor's work was materially aided by Mr. John W. Eckert, a graduate of the Lehigh University, who became first the chemist and afterward the superintendent of the Coplay Cement Company, Mr. Saylor's concern at Coplay Station, which he subsequently left to join in the establishment of the American Cement Company.

While this experiment was being carried on to success in the Lehigh region, and the foundations were being laid for the large industry that now exists, a small works was erected near Kalamazoo, Mich., in 1872. Owing to the character of the material and the high cost of labor and fuel, this works made cement which was too expensive commercially and did not succeed. Early in 1875 works were started by Mr. Shinn at Wampun, Pa., near Pittsburg, using limestone and clay. These works are still going, though they have not been very materially increased since their inception. At South Bend, Ind., Thomas Millen, an Englishman, found a white marl and a blue clay which resemble in composition, though not quite in form, the materials used for cement making in England. He started a small works there in 1877, and the plant is still running, though in a moderate way. Mr. Millen later transferred his field of operations to New York State. The Rockland, Me., lime is well known as one of the best and purest in the country, and it was but natural that the Portland cement industry should seek a lodgment in that field. The Cobb Lime Company, an important concern there,

started works in 1879, but the product was too dear for commercial success, and they were closed down. For similar causes a similar fate overtook the National Cement Company, which was established by Mr. S. D. Coykendall and others on the Hudson, in the well-known natural Rosendale district. Thus it may be seen that out of the six original works started in this country prior to 1881, three were failures, and certainly the industry, with this percentage of loss, did not offer very encouraging outlook to the investor. At this period, the foreign Portland had the market exclusively, and there seemed little likelihood of growth for the American industry.

Patents were necessary to enlist capital in the earlier enterprises, and many of the earlier works were founded on them. The great difficulty in all the American enterprises seemed to be the cost of getting the raw material into powder, then into paste, then into bricks or blocks, and then into the kiln with a sufficient economy. About 1884 and 1885 patents were taken out by Messrs. James M. Willcox, E. J. Smedt and Robert W. Lesley for the purpose of mixing liquid hydrocarbons with the paste. In this way a "slurry" was made which, when compressed into balls or eggs, could be at once put into the kilns, and thus many of the intermediate steps of drying, etc., were dispensed with, and much labor and money saved. These processes, which were used in the works started by the American Cement Company at Egypt, Lehigh County, Pa., under the management of John W. Eckert and Robert W. Lesley, were based upon the use of the by-products of the manufacture of coal gas, but with the introduction of water gas and the consequent advance in the price of coal tar the processes were abandoned and other methods adopted. But the enterprise proved successful, and the Company now controls five large works, four at Egypt, Lehigh County, Pa., and one near Syracuse, N. Y., and is one of the largest producers of Portland cement in the country. While these methods of saving the intermediate processes of drying were being used, other inventions by Mathey, Navarro and Ransome in the same direction gave rise to the establishment of the Atlas

Portland Cement Company, which has two large works in the Lehigh region, and is another great producer of cement. These processes, based originally on the calcination of the crushed raw rock by oil in revolving kilns, were at first unsuccessful, the cement proving unreliable for the same reason that gave Saylor so much trouble originally. Subsequently, however, improvements were made whereby the material was ground to an impalpable powder and slightly moistened before being run through the kiln, and cement made in this way has proved successful, and is made in large quantities in this country.

The above gives a brief account of the development in this country from its inception to its present period of successful manufacture, and, as shown, the industry owes much to the application of American methods and American processes to a European industry. This leads to the discussion of the methods in use in this country and in Europe.

THE HANDLING OF THE RAW MATERIALS.

Materials.—Portland cement in England and in Germany, which are the two largest producing countries, may broadly be stated to be the product of an intimate admixture of chalks and clays or marls and clays. The same condition may be stated to govern the industry in France, as most of the large works in that country use material of similar grade. Both of these materials containing large percentages of hydroscopic water, as well as water in mechanical combination, are treated in what is known as the wet way; by this is meant, that the making of the composition or slurry out of which the Portland cement is produced, is by the mixing of the two ingredients with a considerable portion of water, and in a large number of the European works this percentage of water is so large as to admit of the flowing of the material from place to place in the plant. The production of this intimate mixture of the raw materials in Europe is conducted in pug-mills or slurry-mills of various models, in some cases rollers running over the mixture of clay and chalk and reducing the material to uniform consistency, or in other cases the material being run through millstones in

a wet condition. The material thus reduced was, under the old-time methods in Europe, run into immense settling-basins or vats, covering in some cases many acres, where it was allowed to settle, and where, by evaporation and decantation, it became a mud, showing, after drying, on its surface cracks such as are seen in disused brickyards or pond bottoms where the water has been drawn away. This material, broken up into lumps according to the cracks formed upon the surface, was brought to drying floors, and, after some few days of drying, was put into a kiln with coke and burned to incipient vitrifaction, producing clinker, which was subsequently ground to powder and produced the Portland cement of commerce. Of late years the better practice, which was first instituted in some of the French and better German works, is to more intimately grind the raw materials together, and while in a fluid state to run them into what are called *bassins de dosage*, where a sufficient supply can be held on hand to enable a careful examination to be made of the chemical constituents of the slurry, and from which basins the material is run into other settling-basins, whence it is taken to drying floors, or is pumped into tunnels or on to drying floors forming part of the kilns themselves. As contradistinguished from these processes, which in olden times took several months and under more modern processes in Europe occupy several days and in some cases several weeks, the American practice has been to use dry materials, such as the hydraulic cement, water limestones and lime-rocks of the Lehigh district, and to treat the material in practically a dry way, grinding it together in the form of powder, which is analyzed, and which powder is subsequently made into bricks by machinery or by hand, as stated in the historical portion of this article. Other works dealing with rocks such as are found at Glen Falls, N. Y., and in the New Jersey district near Phillipsburg, use practically the same methods, while mills dealing with marls and clays or wet materials are beginning to run them directly after mixing into *bassins de dosage* and thence into revolving kilns. Thus American practice is enabling mills to manufacture cement by greater econo-

mies in handling the raw materials as a primary and most important step.

Kilns.—Following, therefore, upon this step, the next step to be considered in American practice is that of the kilns, the principal distinctly American kiln in its use being the rotary kiln, already mentioned and which is an adaptation of the English Ransome kiln. This form of kiln was never successfully used in England, and it remained for the Americans to make a commercial success of it. Many of the works using the dry raw materials, however, are also enabled to successfully meet competition by the use of the dome kilns, such as are used in many of the European works, while others use what are known as the Dietsch and Schoefer continuous kilns, both of which are of German origin, and, while affording economy in coal, seem to entail larger labor cost than the use of the dome kilns. Others, as above stated, using the rock of the Lehigh district and also the marls and clays of the Ohio and Michigan districts, have found means of introducing the raw materials finely ground, into rotary kilns, either in a dry or wet condition. In its course from the receiving end of the kiln the damp powder or the slurry is relieved by the heat produced by either oil or pulverized coal from its moisture and carbonic acid gas, until finally the heating power of the kiln further along in its course, clinkers it, and at the discharging end of the kiln the material comes out in the form of small nodules of various sizes and shape and in a clinkered form. This does away with the making of bricks and other forms for the kilns in the case of wet raw material. The forms of these various kilns are very fully described in a new book by Dr. Schoch on the manufacture of cement, published under the auspices of the German Society of Cement Manufacturers, and in a new book by Candlot, Paris, 1897, a thorough description of which burning apparatus would involve considerable in the way of illustration and in technical explanation.

Mills and Crushing Machinery.—Another material point of the difference between the American and European methods, and one to which the very great advance in the product

of this country is due, is in the mechanical apparatus for grinding. European practice has been very largely based upon precedents. The precedents for mills were water-power, and the line shaft for driving mills was usually connected with a water-wheel, and mills were in turn connected with the line shaft by bevels or other forms of cog gearing. Thus the mills in many European works are situated in the second story of the buildings, losing considerable space, and the grinding apparatus in use are the well-known forms of millstones, varying in size from 3 to 6 feet in diameter. In many of the more advanced European plants mills are now driven directly by belts from line-shaft belt, thus taking the place of the old-fashioned cog gearing, and in several of the more modern mills what are known as tube-mills are being used, the apparatus consisting of a revolving cylinder containing a large number of Iceland pebbles. Into this cylinder the clinker is introduced, and, by the revolution of the cylinder and agitation of the pebbles, the material is ground to almost impalpable fineness. Early in the history of the Lehigh district in this country, millstones directly driven by belts and encased in iron frames marked an advance in American grinding methods. This was followed by the introduction in this and other districts of the Sturtevant, Frisbie-Leukop and other forms of iron and steel grinding apparatus, doing away with millstones. Another improvement in American grinding apparatus in this country dates possibly to the introduction of the Griffin mills by the works of the American Cement Company, at Egypt, Pa., somewhere about 1887. This mill is now largely

Griffin Mill.

in use in cement works in this country and abroad, its introduction in European works being very extensive during the past two or three years. The apparatus, as shown by the cut, is very simple in construction, and to it and the other iron mills is due much of the reputation American cement has, of late years, for its extreme fineness and sand-carrying qualities. American Gates crushers and coffee-mill crushers have also shown their superiority, according to the best reports, over similar machinery used in Europe, and in this line the modern works here seem fully equal, if not superior, to many of the leading European works, so far as crushing machinery goes. Having thus noted the differences in the handling of the raw materials, in kilns, and crushing machinery between American and European works making Portland cement, it is next of importance to examine the *American raw materials*, and to note that, notwithstanding their variation in many cases from the raw materials of Europe, that American Portland cement produced from these comes up, in both *chemical analysis* and *standard* tests, to the highest grade of the old-established European brands of Germany, France and England.

AMERICAN RAW MATERIALS.

In the United States raw materials for Portland cement may be said to be very numerous and quite varied. The principal of all the deposits, and the one from which the largest amount of cement is turned out, may be said to be that of the Lehigh hydraulic limestones, above stated, which are found on either side of the Lehigh River, at or around Coplay, and which extend for a considerable distance, and are found farther down across the Delaware, near Phillipsburg, N. J. These rocks are laminated water lime rocks, and by reason of their chemical composition, as well as their structural character are specially adapted to the manufacture of Portland cement. They form a part of what is known as the Silurian argillaceous limestones, a formation which also forms cement rocks for many of the other cement districts. The Glen Falls cement which is made at Glen Falls, N. Y., is made from a lime rock of the Silurian formation, together with clay or clay rock found in

the same vicinity. In New York State, at and around Jordan, Warners and Wayland, the principal ingredient is the white marl of the Silurian formation, while similar materials are also used in the manufacture of cement in the Michigan and Ohio districts. Further west, at San Antonio, Tex. White Springs, Ark., and Yankton, S. D., Portland cement is made from the cretaceous rocks which are found outcropping at various points there and throughout a large territory in the middle West. These with clay, produce excellent cement.

Grouped according to districts and the raw material found therein, the American Portland cement industry may be said to embrace:

(1) *The Lehigh district*, with a total product, according to the figures for 1897, of 1,640,000 barrels, or nearly 75 per cent. of the total output of the country. It extends along the Lehigh River from Siegfried, Pa., to Phillipsburg, N. J., and includes the four mills of the American Cement Company, at Egypt; the two mills of the Coplay Cement Company, at Coplay; the two mills of the Atlas Cement Company, at Coplay and Northampton; the mill of the Hercules Rock Lock and Bonnville Companies at Whitehall and Siegfried, and the mills of the Alpha and Vulcanite Companies, near Whittaker, N. J.

(2) The New York district, embracing the marl and clay raw material plants of the Empire and American Cement Companies, at Warners and Jordan, and the Wayland and the Whittemore, Rauber & Vicinus Works, near Wayland. In addition to these is the Glen Falls (N. Y.) Portland Cement Works, using rock materials.

(3) The Ohio district, including works at Sandusky and Castalia, O., operated by companies of the same name, and using marls and clays, while rock materials are used by the Diamond Cement Company at Middle Branch.

(4) The South Dakota district, with the works of the Yankton Portland Cement Company, using a species of chalk and clay.

The following table, from the "Mineral Industry of the United States," Vol. VI, gives the latest figures on the production of the various districts. The Michigan district uses marl and clay, and several works are going into opera-

tion there, among them the Bronson and the Peerless; the Arkansas district is limited to a single works, at Chalk Cliffs; the Illinois, to a single works, near Chicago, which was recently burnt down; the Texas region to one works, near San Antonio; the Utah, to a single works, near Salt Lake, also recently burnt, and the California, to two small works, at San Diego and Colton, respectively:

PRODUCTION OF PORTLAND CEMENT IN THE UNITED STATES.
(In Barrels of 400 Pounds.)

States.	1896.			1897.		
		Value at Works.			Value at Works.	
	Barrels.	Total.	Per Barrel.	Barrels.	Total.	Per Barrel.
California	8,985	$17,970	$2 00	17,060	$51,180	$3 00
New Jersey	270,658	400,999	1 48	440,454	641,421	1 45
New York	266,482	445,594	1 67	361,594	592,676	1 64
Ohio	163,182	320,364	1 96	147,332	291,640	1 98
Pennsylvania	825,000	1,225,000	1 49	1,200,000	1,740,000	1 45
South Dakota	23,776	47,552	2 00	39,900	75,810	1 90
Texas	15,000	38,000	2 53	7,778	19,912	2 56
Other States (*a*)	4,000	7,000	1 75	58,453	108,850	1 86
Total barrels	1,577,283	$2,502,479	$1 59	2,272,971	$3,521,489	$1 55

(*a*) Includes Arkansas, Illinois, Michigan and Utah.

CHEMICAL ANALYSIS.

The chemical analysis of the American cements, while dealing with materials of different structural character than those which are used abroad, may be said to compare most favorably with the chemical analysis of the European product. It is a well-known fact that the chemical analysis of Portland cement may vary largely in many of its ingredients, owing to the particular kind of materials out of which it is made and their action under the flame of the kiln, but an examination of the table which follows will show that American Portland cements show no material difference from the better grades of the European brands.

The following table gives representative analyses of a number of American Portland cements:

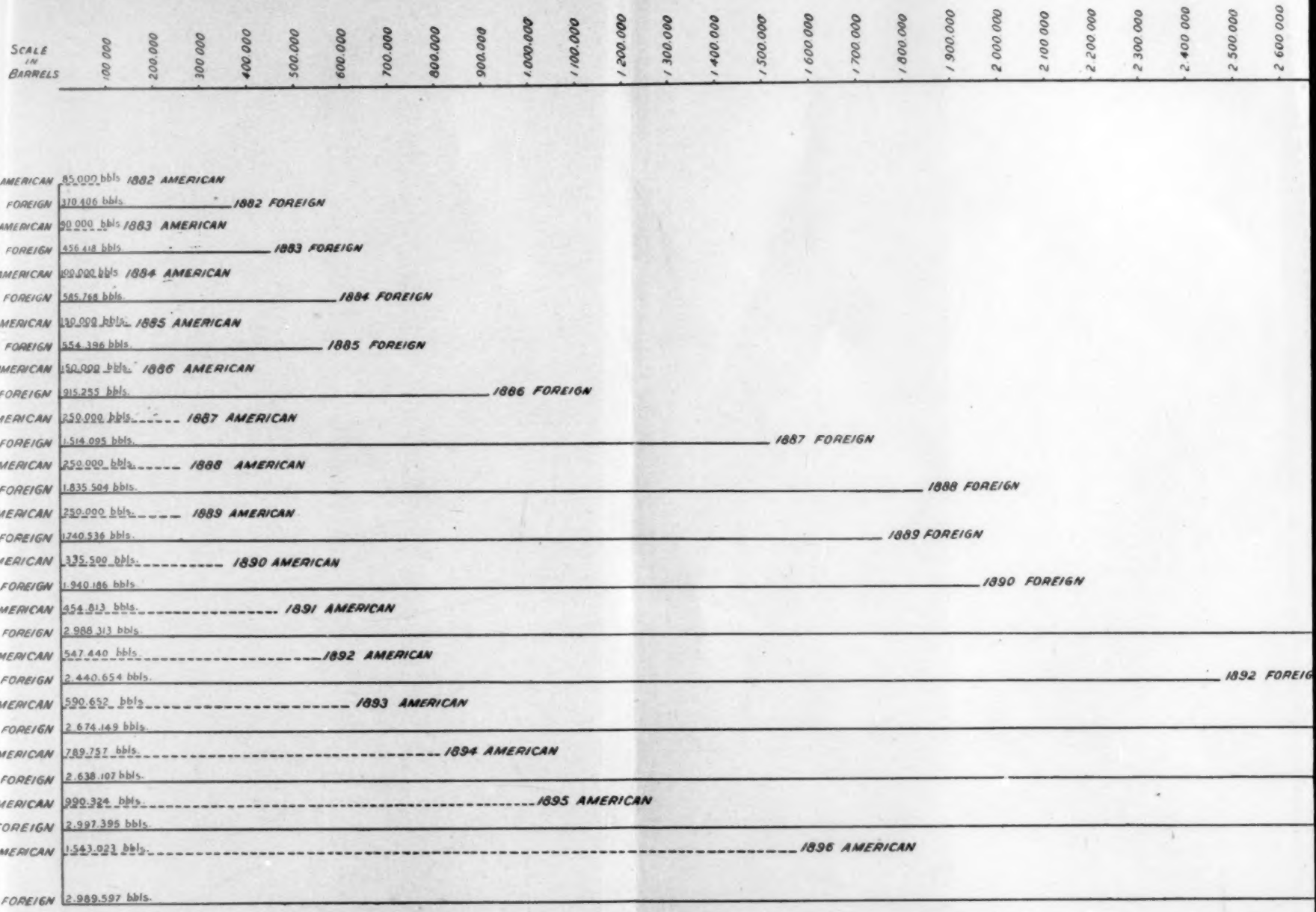


TABLE OF AMERICAN PRODUCTION OF PORTLAND CEMENT 1882–1896 COMPARED WITH IMPORTS FOREIGN PORTLAND CEMENT.

LONG-TIME TESTS ON "GIANT" PORTLAND CEMENT.

BRAND "Giant" Portland	Mode of Mixing.	1 Day		1 Week		1 Mo.		3 Mos.		6 Mos.		9 Mos.		1 Year		15 Mos.		18 Mos.		2 Years		3 Years		4 Years		5 Years		6 Years		7 Years		8 Years		9 Y
		Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.
*Sodom and Bog Brook Dams, New York Aqueduct. About 50,000 bbls.	Neat	1,025	140	1,398	348	220	422	180	540	100	634	30	638	180	682	30	687	110	672	110	694	90	736	60	771	*4	646	*6	583	*2	585	2	749	2
	2 to 1	...	...	220	166	120	280	140	364	84	468	50	468	90	490	36	526	100	580	100	564	130	680	120	674									
	3 to 1	...	...	226	140	140	234	112	350	110	428	30	428	240	420	40	500	80	514	80	512	160	572	...	...	*4	486	*5	491	*1	618			
Titicus Dam, New York Aqueduct. About 100,000 bbls.	Neat	3,448	157	4,165	380	637	476	505	529	478	575	479	599	350	642	181	594	135	584	137	641	62	668	54	699	64	704	6	647	...	...	...	...	...
	2 to 1	...	...	2,934	200	424	317	281	450	321	491	278	532	219	549	157	557	92	541	52	586	37	573	13	565	38	610	5	631					
	3 to 1	...	...	1,604	115	260	185	450	289	133	347	146	311	132	426	70	424	66	416	126	419	7	483	56	539	42	540	5	611					
Carmel and Craft's Dams, New York Aqueduct. About 40,000 bbls.	Neat	1,786	140	1,075	343	324	443	551	517	529	548	491	568	289	617	...	...	273	604	211	611	...	...	...	...	...	...	...	...	...	...	...	...	...
	2 to 1	...	...	1,642	182	216	308	85	445	87	480	76	472	43	585	...	...	49	477	55	475	3	538											
	2 to 1 from Mortar Box	...	...	61	164	51	237	8	385	11	494	8	491	7	367	...	...	12	516	3	568													
	3 to 1	...	...	13	100	13	174	7	319	12	372	11	398	10	413	...	...	8	401	10	406													
	3 to 1 from Mortar Box	...	...	45	112	31	166	6	310	8	480	7	500	9	541	...	...	7	437	5	406													
Reading Terminal Railroad and Station, Philadelphia. About 80,000 bbls.	Neat	...	...	329	315	267	376	69	451	15	549	16	576	10	523	1	640	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	3 to 1	...	...	536	79	431	129	104	174	20	228	15	225	47	261	5	287																	
	2 to 1 from Mortar Box	...	...	190	84	180	144	17	219	13	234	25	281	62	325	12	417																	
Niagara Falls Tunnel, Niagara Power Co. 80,000 bbls.	Neat	...	...	495	321	309	420	12	514	24	562	...	...	24	661	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	2 to 1	...	...	482	152	271	242	54	369	20	454	...	...	7	472																			
	3 to 1	...	...	527	98	399	177	143	254	181	301	...	...	12	391																			
Cornell Dam, New Croton Aqueduct. Largest masonry dam in the world. About 65,000 barrels.	Neat	2,677	186	2,699	413	405	525	190	559	110	600	120	601	105	679	55	713	53	679	36	722													
	2 to 1	...	...	2,624	303	415	432	180	558	110	664	110	663	90	707	43	700	53	701															
	3 to 1	...	...	...	...	...	...	...	...	...	...	...	...	10	482	10	529	5	534															
District of Columbia. Giant (Egypt).	Neat	...	188	....	278																													
	3 to 1	...	...	...	159	...	205	...	240	...	341	...	360	...	394	...	...	...	...	...	417													
Metropolitan Water Board of Boston, Mass. Over 15,000 barrels.	Neat	1,510	293	617	453	40	486	20	540	5	567	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	2 to 1	....	...	616	282	40	339	20	438	5	549																							
Department of Public Works, Philadelphia, Pa. Giant. Over 20,000 barrels.	Neat	...	249	412	500	...	...	...	...	...	592	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	3 to 1	...	89	....	175	...	252	...	...	...	311																							

*Note.—Up to 4 years briquettes at Sodom were broken in the Laboratory on the Dam. Subsequently they were broken at Cornell Dam, after having been out of water fo
some months, between October, '93, and June, '94, which explains the temporary falling off.

ESTS ON "GIANT" PORTLAND CEMENT.

s.	1 Year		15 Mos.		18 Mos.		2 Years		3 Years		4 Years		5 Years		6 Years		7 Years		8 Years		9 Years		
pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Number of Briquettes.	Average, in pounds.	Residue on No. 50 sieve, 2,500 holes to
38	180	682	30	687	110	672	110	694	90	736	60	721	*4	646	*6	583	*2	585	2	749	2	817	. . .
68	90	490	36	526	100	530	100	564	130	680	120	674											
28	240	420	40	500	80	514	80	512	160	572	. . .	. . .	*4	486	*5	491	*1	618					
99	350	642	181	594	135	584	137	641	62	668	54	699	64	704	6	647	. . .	. . .	. . .	. . .	. . .	. . .	. . . . .
32	219	549	157	557	92	541	52	586	37	573	13	565	38	610	5	631							
11	132	426	70	424	66	416	126	419	7	483	56	589	42	540	5	611							
68	289	617	. . .	. . .	273	604	211	611	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . . . .
72	43	585	. . .	. . .	49	477	55	475	3	538													
91	7	367	. . .	. . .	12	516	3	568															
98	10	413	. . .	. . .	8	401	10	406															
00	9	541	. . .	. . .	7	437	5	406															
76	10	523	1	640	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	.090
25	47	261	5	287																			
81	62	325	12	417																			
. .	24	661	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . . . .
. .	7	472																					
.	12	391																					
01	105	679	55	713	53	679	36	722															
63	90	707	43	700	53	701																	
. .	10	482	10	529	5	534																	
60	. . .	394	. . .	. . .	. . .	. . .	. . .	417															
. .	. . .	. . .	. .	. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1.0
. .	. . .	. . .	. .	. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1.8

ratory on the Dam. Subsequently they were broken at Cornell Dam, after having been out of water for temporary falling off.

Industry in the U. S.)

9 Years		FINENESS.		
Number of Briquettes.	Average, in pounds.	Residue on No. 50 sieve, 2,500 holes to sq. in.	Residue on No. 74 sieve, 5,180 holes to sq. in.	Residue on No. 100 sieve, 10,000 holes to sq. in.
2	817	.....	.....	18.0
...	...	.....	.....	11.7
...	...	.....	... ..	14.7
...	...	.090	10.04	14.79
...	...	.. ...	.....	14.9
...	...	1.0	.....	9.8
...	...	1.3	.....	8.6

ter for

Brand of Cement.	SiO_2 Per Cent.	Al_2O_3 Per Cent.	Fe_2O_3 Per Cent.	CaO Per Cent.	MgO Per Cent.	SO_3 Per Cent.	Authority.
Alpha	22·62	8·76	2·66	61·46	2·92	1·52	Booth, Garret & Blair.
Atlas	21·96	8·29	2·67	60·52	3·43	1 49	" " "
Giant	19·92	9·83	2·63	60·32	3·12	1·13	" " "
Saylors	22·68	6·71	2·35	62·30	3·41	1·88	" " "
Vulcanite	21·08	7·86	2·48	63·68	2·62	1·25	" " "
Empire	22·04	6·45	3·41	60·92	3·53	2·73	" " "
Jordan	21·86	7·17	3·73	61·14	2·34	1·94	" " "
Diamond	21·80	7·95	4·95	62·90	1·64	0·79	" " "
Sandusky	23·08	6·16	2·90	62·38	1·21	1·66	" " "
Bronson	20·95	9·74	3·12	63·17	0·75	0·86	Mfr.'s Analysis.
White Cliffs, Ark. .	22·93	*10·33		64·67	0·94	1·05	" "

* Alumina and iron together.

For comparison, the following analyses of European cements are given:

Brand of Cement.	SiO_2 Per Cent.	Al_2O_3 Per Cent.	Fe_2O_3 Per Cent.	CaO Per Cent.	MgO Per Cent.	SO_3 Per Cent.	Authority.
White Label, Alsen .	20·48	7·28	3·88	64·30	1·76	2·46	Booth, Garret & Blair.
Dyckerhoff	20·64	7·15	3·69	63·06	2·33.	1·39	" " "
Germania	22·08	6·84	3·36	63·72	1·32	1·82	" " "
Hemmoor	21·14	6·95	4·01	63·24	1·44	1·47	" " "
Lagerdorfer	23·33	7·47	2·40	61·99	1·42	1·07	" " "
B. Shoobridge Co. .	22·20	7·35	4·77	61·46	1·35	1·86	" " "
Francis	22·18	8·48	5·08	61·44	1·34	1·56	" " "
Condor	23·87	6·91	2·27	64·49	1·04	0·88	" " "
Candlot, French . .	22·30	8·50	3·10	62·80	0·45	0·70	Candlot.
Boulogne, French .	22·30	7·00	2·50	64·62	1·04	0·75	"

(From the "Mineral Industry of the United States," Vol. VI.)

TESTING OF AMERICAN PORTLAND CEMENT.

For purposes of comparison between the cement of American and European manufacture, tables are given herewith of results of tests on a number of brands in actual use on the Nashua Aqueduct of the Metropolitan Water System, of Boston, Mass., and the public work of the United States Government in the District of Columbia.

FROM REPORT ENGINEER DEPARTMENT OF THE DISTRICT OF COLUMBIA FOR UNITED STATES GOVERNMENT FOR YEAR ENDING JUNE 30, 1897.

Brand of Portland Cement.	Tensile Strength.						
	Neat.		3 Parts Quartz.				
	1 Day.	7 Days.	7 Days.	1 Month.	6 Months.	1 Year.	2 Years.
Alpha, "American"	—	—	105	182	327	350	—
Alsen	292	635	188	310	390	366	371
Atlas, "American"	432	768	321	441	538	546	523
Dufossez and Henry, "Belgian"	149	546	139	188	319	332	335
Dyckerhoff, "German"	345	566	164	175	298	323	370
Egypt, "American"	188	278	159	205	341	394	417
Giant, "American"	160	495	230	275	325	327	342
Hannover, "German"	295	571	205	244	315	354	—
Hemmoor, "German"	295	657	159	203	314	347	355
Mannheimer, "German"	329	525	193	226	343	336	—
Porta, "German"	407	415	181	257	343	329	349
Saylor, "American"	201	461	135	156	289	279	—

REPORT 1897 ENGINEER NASHUA AQUEDUCT, BOSTON METROPOLITAN WATER BOARD.

Brand.	Composition of Briquette.	Fineness.			Tensile Strength.					
		Per Cent. Residue on No. 50 Sieve, 2,500 Meshes to Sq. Inch.	Per Cent. Residue on No. 100 Sieve, 10,000 Meshes to Sq. Inch.	Per Cent. Residue on No. 150 Sieve, 22,400 Meshes to Sq. Inch.	1 Day.	7 Days.	28 Days.	3 Mos.	6 Mos.	1 Year.
					Pounds Per Sq. Inch.	Pounds Per Sq. Inch.	Pounds Per Sq. Inch.	Pounds Per Sq. Inch.	Pounds Per Sq. Inch.	Pounds Per Sq. Inch.
Atlas, "American"	Neat	.4	9.9	24.7	392	677	712	729	792	—
	2 to 1	—	—	—	—	325	356	342	346	—
Brooks, Shoobridge, "English"	Neat	1.0	11.4	26.0	184	443	442	527	585	691
	2 to 1	—	—	—	—	255	311	398	424	490
Giant, "American"	Neat	1.0	9.8	21.8	293	453	486	540	567	—
	2 to 1	—	—	—	—	282	339	438	549	—
Iron-clad, "American"	Neat	.3	8.5	26.0	404	537	535	604	714	—
	2 to 1	—	—	—	—	323	354	400	409	—
Settin, Girstower, "Gertman"	Neat	2.8	17.9	30.9	288	570	596	646	674	666
	2 to 1	—	—	—	—	373	361	379	372	402
West Kent, "English"	Neat	1.7	18.6	31.1	178	356	456	521	547	588
	2 to 1	—	—	—	—	261	326	410	534	547
Total	Neat	.8	10.7	24.7	321	517	552	588	623	628
	2 to 1	—	—	—	—	295	341	393	416	491

These tables show that in fineness American Portlands considerably excel the imported brands, and also excel them in neat and sand mortars in many cases at both short and long time tests.

In reply to the one vital question which may be asked of the American Portland cement manufacturer—will your cement stand the test of time?—the following table, showing a record on nearly half a million barrels of one American Portland cement up to periods of from one to nine years, shows that American Portland cement meets all the requirements of stability and permanence, and has, in fact, "come to stay."

GROWTH OF THE INDUSTRY.

THE GROWTH OF THE INDUSTRY may be best illustrated by the accompanying photograph, which shows a series of cement barrels, each barrel representing the American product of Portland cement for a certain year, as shown by the report of the United States Geological Survey of 1896. These differences are shown by the *height* of the barrel only, the scale being that of *height* and not *cubical* contents of the several barrels, but the relative *height* of the barrel will give to the eye a thorough impression of how the production of American cement has grown within the past fifteen years. Possibly a better method, however, of arriving at the growth of the American industry is afforded by an examination of the photograph which is shown below, in which the American output and the foreign imports are by years grouped together, and indicated by straight and dotted lines. This conveys to the eye the growth of the American product.

The figures are those of the United States Geological Survey and show how rapidly the American production of Portland cement is overtaking the importation of the foreign article.

It can be readily seen by the above that the percentage of American Portland to the imported is steadily rising, and while the figures for 1897 of the United States Geological Survey are not yet ready, the "Mineral Industry" for 1897

Year, 1882 1890 1891 1892 1893 1894 1895 1896

TABLE SHOWING BY COMPARATIVE HEIGHT OF A CEMENT BARREL, THE GROWTH OF THE AMERICAN PORTLAND CEMENT INDUSTRY.

shows that, practically, the American production has overtaken the importation of the foreign article.

They are as follows:

1897. BARRELS OF 400 POUNDS.

	Barrels.
American Production	2,272,971
Importation foreign cement	2,090,760

The following table shows the products, imports, exports and consumption of all grades of cement, natural and Portland, for the past five years for "Mineral Industry of the United States." The figures vary slightly from those of the United States Geological Survey.

CEMENT PRODUCTION, IMPORTS, EXPORTS, AND CONSUMPTION IN THE UNITED STATES.

(In Barrels of 300 Pounds.)

YEAR.	PRODUCTION.				IMPORTS.		EXPORTS.		CONSUMPTION.	
	Natural Hydraulic.	Portland.	Total Barrels.	Value.	Barrels.	Value.	Barrels.	Value.	Barrels.	Value.
1892	8,211,181	547,440	8,758,621	$7,152,750	3,254,183	$3,376,824	107,894	$169,538	11,905,000	$10,361,543
1893	7,445,950	673,989	8,119,939	6,063,131	3,565,532	3,470,169	112,518	174,663	11,573,451	9,358,737
1894	7,595,259	738,196	8,633,455	5,478,051	3,540,820	3,396,729	120,967	180,881	12,137,955	8,859,708
1895	7,694,053	998,745	8,692,798	6,027,374	3,996,520	3,873,123	95,559	131,541	12,676,798	9,931,572
1896	7,407,311	2,103,044	9,510,355	6,888,441	3,561,160	3,394,436	69,632	103,315	12,195,959	9,369,700
1897	7,781,377	3,030,628	10,812,005	7,648,613	7,787,760	2,688,122	61,759	103,389	13,538,006	10,233,346

The growth of the consumption of cement given by periods of ten years is as follows:

Year.	Pounds per capita.
1850	6·46
1860	10·49
1870	12·77
1880	13·04
1890	33·93

Generally, therefore, it may be safely said that the cement industry is growing rapidly, but most especially is this the case with the manufacture of Portland cement, the production of which this year is expected to largely exceed the importations.

It seems only a question of time when the American Portland will ultimately supersede in most of our home markets the foreign article. The manufacture may be said now to be an established industry in the United States, and one deserving the success that it has shown its right to have. Its capabilities are very large, and its past has shown that its development will depend upon careful management, both scientific and practical, inasmuch as the successful works have won their success upon these elements, as well as upon their proper geographical location with regard to raw materials and proper distributing markets.

DISCUSSION.

MR. RICHARD L. HUMPHREY.—I do not feel that I can contribute anything further on the industry of Portland cement. I have listened with a great deal of interest to what Mr. Lesley has said concerning the development of this industry. He is thoroughly conversant with this subject, and he has presented it to you in his usual clever style.

In the matter of testing cements I can add a few remarks which may perhaps be of interest. All cement used by the city of Philadelphia is subjected to careful inspection. The city consumes, each year, about 120,000 barrels of natural cement and about 50,000 barrels of Portland cement. For sewers, foundations for street pavements, etc., natural cement is used, while for the more important works, bridges, bulkhead walls and concrete in large masses, Portland cement is used. The natural cement to which I refer is not the natural cement referred to by Mr. Lesley, and which is usually known as Roman or Rosendale cement, but it is an improved or high-grade natural cement, fully 50 per cent. stronger than what is usually known as natural cement. For the class of work referred to, the city finds this cement to be durable and very economical.

Since my connection with the city, during which time the testing laboratory has been established and developed, there has been a gradual improvement in the quality of the cement submitted for use in public work.

This can be said to be due (1) to the maintenance of a testing laboratory and the enforcement of rigid tests, and (2) to improvements in the quality of the cement, due to improvements in the process of manufacture.

In 1892, where Portland cement was required, the city used almost exclusively foreign Portland cement. Each succeeding year witnessed a gradual improvement in the quality of American Portland cement, accompanied by a corresponding decrease in the consumption of foreign Portland cements.

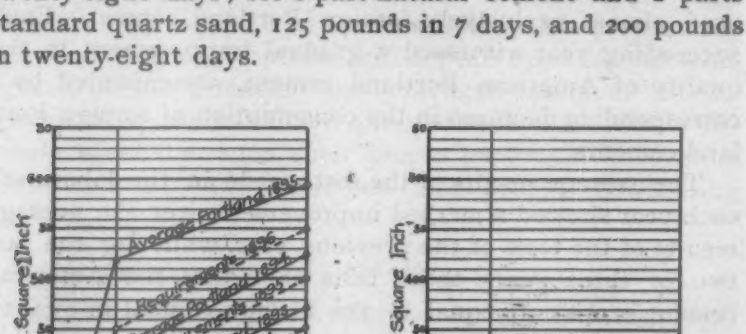
The average results of the tests made in the laboratory each year showed a marked improvement over the average results of the tests of the previous year, while for the last two or three years these tests show that the American cement is not only equal to the foreign cement in quality, but superior to it.

This improvement in the quality of the American cements has also been accompanied by a decrease in the price of the cement.

In 1892 high grade foreign Portland cement brought from $2.45 to $2.85 per barrel, while natural cements brought from $1.20 to $1.40 per barrel. These foreign cements were gradually supplanted by the high grade American cements, until in 1897, American Portland cement brought on an average $1.90 per barrel (in bags), and in some cases as low as $1.50 per barrel (in bags), while natural cement brought on an average 95 cents per barrel (in bags), and as low as 85 cents per barrel (in bags). Foreign Portland cement of the same grade ranged in price from $2.15 to $2.85 per barrel.

In 1892 the city required Portland cement, when tested neat, to yield a tensile strength of 300 pounds per square inch in seven days, while natural cement was required to show 120 pounds at the end of the same period of time. The specifications were increased each year, as was shown to be necessary by the average tests made during the year, until to-day the requirements are: for neat Portland cement 175 pounds in twenty-four hours, 500 pounds in seven days, and 600 pounds in twenty-eight days; for 1 part Portland

cement and 3 parts standard quartz sand, 170 pounds in seven days, 240 pounds in twenty-eight days. For natural cement the requirements are: neat, 100 pounds in twenty-four hours, 200 pounds in seven days, and 300 pounds in twenty-eight days; for 1 part natural cement and 2 parts standard quartz sand, 125 pounds in 7 days, and 200 pounds in twenty-eight days.

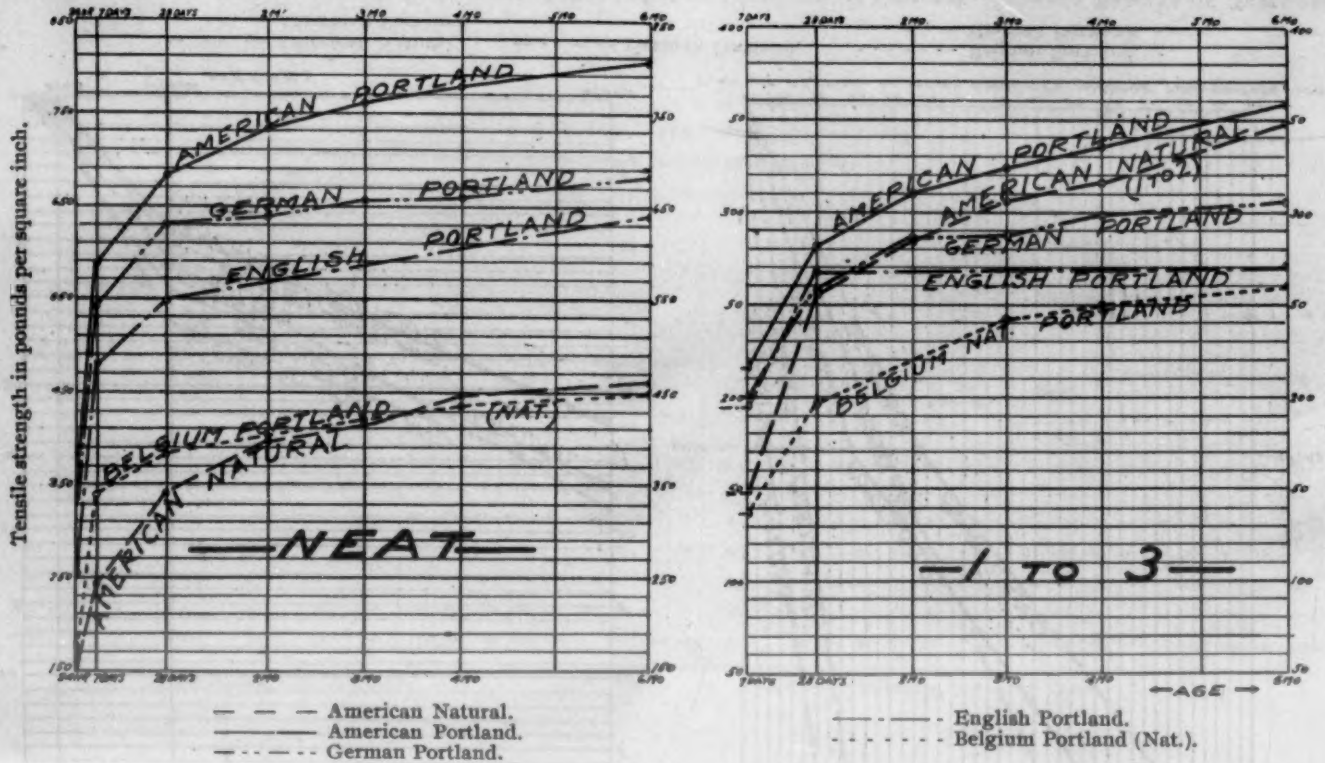


The city is using to-day cement over 50 per cent. stronger than that used during 1892, and at a cost of from 50 to 60 cents per barrel less. Nearly every barrel of this material is American cement.

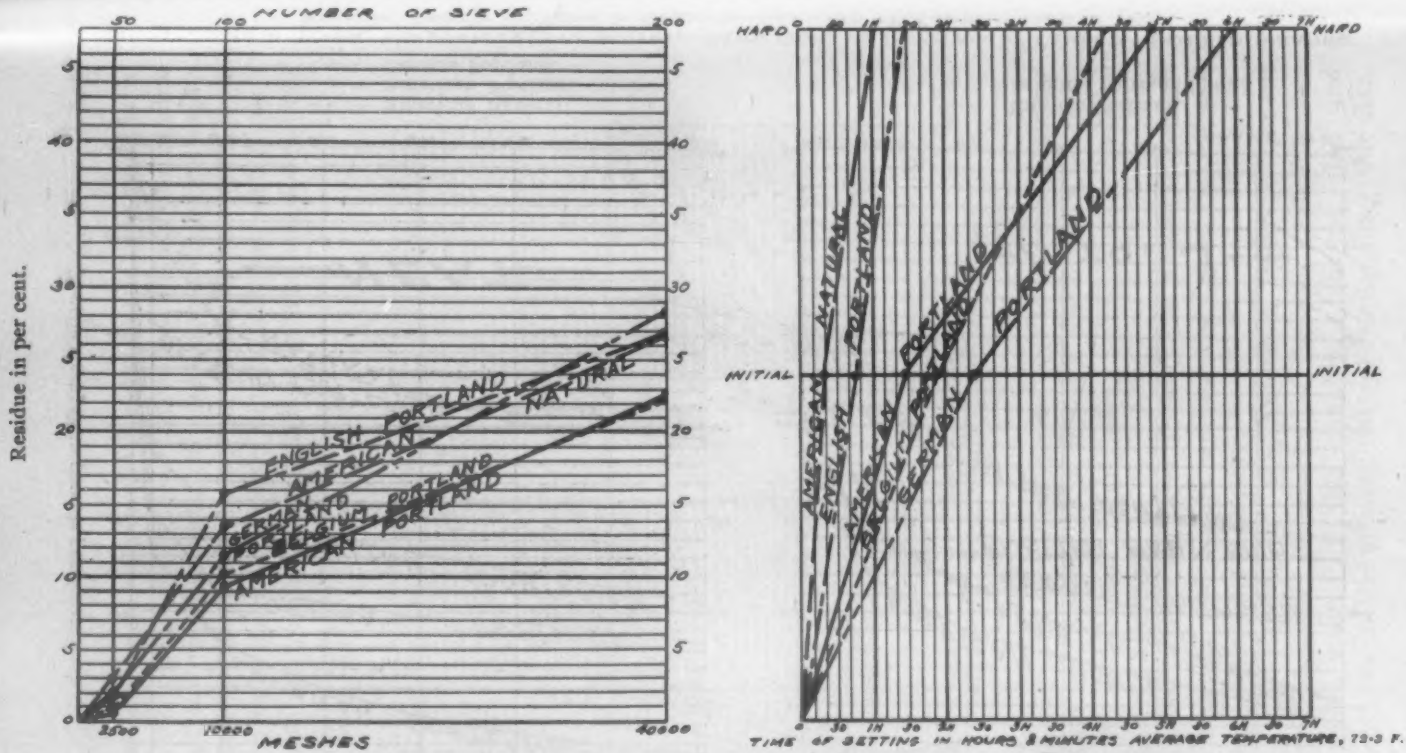
This is certainly very creditable to the American cement manufacturers, and argues well for the future success and development of this industry.

The development of the American Portland cement industry is another illustration of the fact, that when an industry is started in this country, American skill and ingenuity eventually succeed not only in equaling, but also,

DEPARTMENT OF PUBLIC WORKS—BUREAU OF SURVEYS—LABORATORY OF INSPECTOR OF CEMENTS—DIAGRAM SHOWING AVERAGE RESULTS OF TESTS OF CEMENTS—NEAT AND WITH SAND—MADE IN 1897.



DEPARTMENT OF PUBLIC WORKS—BUREAU OF SURVEYS—LABORATORY OF INSPECTOR OF CEMENTS—DIAGRAM SHOWING AVERAGE RESULTS OF TESTS OF CEMENTS—NEAT AND WITH SAND—MADE IN 1897.



— — — American Natural. —— American Portland. —·—·— German Portland. ····· Belgian Portland. — — — English Portland.

DEPARTMENT OF PUBLIC WORKS—BUREAU OF SURVEYS—LABORATORY OF INSPECTOR OF CEMENTS—AVERAGE RESULTS OF TESTS—FOR FINENESS AND TIME OF SETTING—MADE IN 1897.

DEPARTMENT OF PUBLIC WORKS—BUREAU OF SURVEYS.

LABORATORY OF THE INSPECTOR OF CEMENTS.

Requirements of Specifications for Cement for Years 1893 to 1897.

YEAR.	PORTLAND CEMENT.													NATURAL CEMENT.										
	Fineness. Per Cent. of Residue on Sieve.			Time of Setting in Minutes. Temperature 60°–70° F.		Ultimate Tensile Strength in Pounds Per Square Inch.								Fineness. Per Cent. of Residue on Sieve.			Time of Setting in Minutes. Temperature 60°–70° F.		Ultimate Tensile Strength in Pounds Per Square Inch.						
						Neat.			Standard Sand. 1 to 3.		Mixing Box.								Neat.			Standard Quartz Sand.				Mixing Box. 1 to 2.	
											1 to 2.		1 to 3.									1 to 1.		1 to 2.			
	No. 50	No. 100	No. 200	Initial	Hard	24h	7d	28d	7d	28d	7d	28d	7d	28d	No. 50	No. 100	No. 200	Initial	Hard	24h	7d	28d	7d	28d	7d	28d	7d	28d
1893 . . .	4	—	—	—	—	—	300	—	—	—	—	—	—	—	4	—	—	—	—	75	130	—	—	—	—	—	—	—
1894 . . .	1	15	40	30	—	125	350	450	125	—	—	—	—	—	4	25	40	10	30	75	150	250	50	—	—	—	30	—
1895 . . .	1	15	40	30	—	175	400	500	150	200	150	—	—	—	4	20	40	10	30	75	175	275	—	—	100	175	50	125
1896 . . .	1	10	30	30	—	175	450	550	160	220	125	200	—	—	3	15	35	10	30	100	200	300	—	—	120	200	50	125
1897 . . .	1	10	30	30	—	175	500	600	170	240	—	—	225	275	2	15	35	10	30	100	200	300	—	—	125	280	50	125

G. S. WEBSTER, *Chief Engineer.*

RICH'D L. HUMPHREY, *Inspector of Cement.*

as in this case, in excelling the foreign product both in quality and cheapness.

MR. JAMES CHRISTIE.—The statistics given by Mr. Lesley indicate what an important element of industry hydraulic cement has become. For some work it is indispensable, and for any purpose it is so much superior to lime mortar that it hardly pays to use the latter at all. The use of concrete for foundations of structures and machinery has become so universal that the occupation of the stone mason is much diminished. One of the many advantages of the use of cement concrete is that it can be so readily moulded into any desired form; an important saving in time can be effected over that required for laying of masonry.

Recently, I had a foundation for a large machine to put in. The exigencies of the case required the work to be completed in a single day, which was readily done; whereas, I am confident the same work laid in stone could not have been completed in the given time if all the masons that could have been crowded into the space had worked on it. When a light concrete is required a porous furnace slag can be used; or, on the contrary, if weight and great crushing strength is needed, trap rock makes the best body for the concrete. When a very strong and heavy concrete is desired, I have used a concrete of the ordinary composition, into which is incorporated iron cuttings from $\frac{1}{8}$ to $\frac{1}{2}$ by weight of the whole mass, and 1 pound of sal-ammoniac to each 50 pounds of iron. This concrete will weigh 210 to 220 pounds per cubic foot, and in one month will resist a crushing force of 3,000 pounds per square inch of surface, or about six times that of ordinary concrete.

Stated Meeting, April 13, 1898.

THE REDUCTION WORKS FOR SILVER ORES AT ADUANA, SONORA, MEXICO.

BY MILTIADES TH. ARMAS,
Formerly Assistant Superintendent.

[*Concluded from p. 302.*]

Sulphides.—Twice a week all the accumulated sulphides are thrown upon a cloth filter in a vat with a false bottom, and dried. This sulphide is calcined in a reverberatory furnace at a very low temperature, and then incorporated in the cupellation with litharge.

$$AgS + 2PbO = Ag + 2Pb + SO_2.$$

The average grade of the sulphide for the fourth trimester of 1897 was:

	Per cent.
Ag	24·1
S	31·0

Experiment.—An experiment made to recover the sulphur from the sulphide, and which gave a promising result, was the following:

11·75 pounds of sulphide treated with lime and boiled with steam for an hour gave 54 liters of calcium polysulphide solution of 2° B. with 5·380 grams of sulphur per liter, and the residue was incorporated in the cupellation without any difficulty, any excess of lime in the remaining sulphide coming out of the cupel with the litharges.

Sulphur being dear in Mexico, a partial recovery of the sulphur and further experimenting to solve the problem in a way adaptable to the conditions of the country, is necessary.

Cementation of the Copper in the Leaching Waters.—For a long time these solutions were discarded. Experimental work, however, proved that the free iron, which is always

found in mattes of lead smelting, would easily precipitate the copper found in the solution as chloride or sulphate, besides the silver that it may contain. Furthermore, the mattes were to be exported, provided they contained a sufficient amount of copper to pay the expense of freight and duties, the real profit coming from the silver contained in them. It was decided, therefore, to enrich the mattes destined to exportation by allowing all the leaching waters to pass over them. The results were very satisfactory, I am glad to say, as mattes of 35 per cent. of copper could be enriched to 40 per cent.

Concentration.—Ores of a grade between 23 and 27 ounces per ton are treated by wet crushing in a 10-stamp battery, and the pulp passes through a 30-mesh screen.

Capacity of the 10-stamp mill: 19·8 tons per twenty-four hours; 17·0 gallons of water per minute.

The crushed ore passes to a hydrometric sizer, and thence to three rubber belt Frue vanners, each 6 feet in width. The one which receives the coarser stuff is corrugated, and its capacity is double the other.

The principal difficulty experienced in the concentration was the floating gray copper, which could not easily be recovered. Attempts of various kinds have been made, but with little success. The losses sustained thereby were as high as thirty per cent.

Adoption of more complex and perfect concentrating machinery could not be thought of, as the Company was not willing to undergo further expenses. To that must be added the scarcity of water, which, towards the approach of the rainy season becomes so great, as to cause the stoppage of concentration. Only local and inexpensive means to reduce the losses could be adopted.

We first changed the screen to No. 24, in order to reduce the extreme division of galena and gray copper. This reduced the losses by 30 per cent., mainly by the recovery of galena, but the loss in gray copper, owing to its cleavage, could not be avoided entirely.

Round-buddles were resorted to, but not with perfect success. However, I have reasons to believe that were it

not for other numerous occupations, and especially in the smelting department, which afforded me but little time, the round-buddle could give satisfactory results if tested thoroughly.

During the last six months of 1897 we treated: 2,389 tons of ore, containing 65,321 ounces concentrates; obtained 410,072 pounds, containing 48,768 ounces concentrates.

Cost per ton of ore treated:

Labor in crushing	$0 30
Crushing	37
Labor at the concentration	51
Store expenses	24
Machines, pumps, etc.	10
	$1 52

ANALYSIS OF THE CONCENTRATES.

	Per Cent.
SiO_2	12·
Pb	19·1
Cu	12·1
S	22·2
Zn	21·0
Al_2O_3	1·2
CaO	0·9
Sb	3·2
As	4·1
Fe	2·9

Agglomeration of the Concentrates.—Agglomeration of the concentrates with slag from the lead smelter, while very liquid, proved a failure.

On the other hand, a preliminary roasting in a brick form was desirable, not only with a view of getting rid of some of its harmful elements, as S, As, and Sb, but also to give it solidity. To that effect experiments on various scales were made.

Agglomeration with clayish earth (a product of decomposition of rhyolite) of the following composition was made.

	Per Cent.
SiO_2	54·0
Al_2O_3	18·6
Fe_2O_3	15·4
CaO	2·2
H_2O	8·6

Fine charcoal coming from the screening of the fuel for the smelter was added in the proportion of 8–10 per cent., which rendered the brick porous and afforded economy of fuel. The quantity of clay which gave the best results in the agglomeration was 13 per cent.

	Per Cent.
Clay	13
Charcoal	8
Concentrates	79
Size of the bricks	8″ x 3″ x 1″

These bricks were made by Indians and dried in the sun. Very careful and slow roasting in stall gave the desired consistency and volatilization of some S, Sb and As, but the loss in silver was great.

ANALYSIS OF A BRICK OF CONCENTRATES.

	Per Cent.
SiO_2	22·4
Fe	4·2
Al_2O_3	4·0
CaO	4·0
S	11·4
Pb	16·6
Cu	8·6
Zn	20·6
As	2·1
Sb	2·4
Ag	0·52

Smelting.—All the ores of a grade superior to 130 ounces per ton, as well as the concentrates, are smelted in a water jacket furnace of the following dimensions:

Diameter	39″
Capacity	40 T
Number of tuyeres	6
Root blower	N° 4
Blast pressure	1½″
Number of revolutions per minute	between 100 and 120
Volume of air blown per revolution	13 cubic feet
Diameter of blast pipe	14″

The ores smelted were complex. The chief difficulty arises from the high percentage of Zn, As and Sb.

Analysis.—

IRON ORE.

SiO_2	6·6	SiO_2	23·2
Fe	57·0	Fe	41·0
Al_2O_3	3·2	CaO	5·6
CaO	2·1		

LIMESTONE.

SiO_2	10·0
Al_2O_3	0·8
Fe_2O_3	3·4
CaO	47·0
CO_2	37·0
H_2O	1·8

I will not describe the details of smelting, because they are so well known, but only mention the difficulties with which we had to contend.

As we go deeper in the mine the ore is becoming more blendiferous. The concentrates also proved to be rich in zinc. No roasting of the ore could be done successfully as the losses in silver by volatilization were great, as is the case with rich ores.

For the zinc there was only one remedy in ordinary smelting, that of diluting it with a large amount of slag. Slag containing more than 8 per cent. of Zn did not give satisfactory results, but a large amount of slag, cost in fuel, time and iron, neither of which is cheap. On the other hand, as we had to contend with Indian unskilled workmanship, we were liable to be the victims of their carelessness, especially with ores containing such a large percentage of Zn and As.

The speiss formed (As,Fe) is not readily fusible and not liquid when melted, forms hearth-accretions, and prevents a good separation of lead. To prevent this it is necessary to select a slag that requires a great heat for its formation, and fuel is dear in Aduana. Furthermore, any neglect on the part of the Indian at the tap-hole, for instance, by not keeping it in the proper level and nearer to the hottest part of the furnace, is liable to cause the speiss floating on the lead beneath the matte to chill. The scarcity of iron ore and

fuel, and the accidents mentioned above, compelled us to resort to matte smelting with as little flux as possible, trying, however, to obtain all the silver in the base bullion as long as the hearth was kept in good condition.

By operating in that manner we could get rid of the greater part of Zn and As. In a second operation, re-smelting the mattes, most of the lead and silver were recovered and the mattes themselves reconcentrated to about 40 per cent. of copper, which would pay very well to export.

In direct smelting, counting accidents and the large consumption of fuel (about 26 per cent.), to say nothing of the losses in silver by volatilization, the cost was greater than by smelting first for mattes and then re-smelting the same. Indeed, the latter required a lower temperature, was easier to smelt and did not cause important volatilization of silver. The consumption did not exceed 23 per cent. in both operations together.

In direct smelting, when it was attempted to extract the greater part of the silver, the matte could not be exported at a large profit. The figures below indicate the composition of mattes by the first and second methods of operation:

DIRECT SMELTING.

Mattes.	A Per Cent.	B Per Cent.
Cu	29·0	27·6
Fe	28·1	27·9
Pb	12·9	15·1
S	22·7	20·9
Zn	5·3	4·8
Ag	227·5 ounces per ton,	169 ounces per ton.

BY THE METHOD OF SMELTING FIRST FOR MATTE.

	C Per Cent.	D Per Cent.
Cu	42·8	41·9
Fe	21·0	20·4
Pb	9·2	10·1
S	22·1	23·4
Zn	2·0	1·9
Ag	97·5 ounces per ton,	130 ounces per ton.

TABLE OF LEAD BULLION.

Number of Pile.	Weight in Mexican Pounds.	Ounces per 300 Pounds.	Ounces Contained.
8-1	4,084	46·6	634
8-2	5,380	38·8	695
8-3	5,795	54·6	1,053
8-4	5,526	50·0	920
8-5	8,058	45·0	1,206
8-6	6,745	51·0	1,142
8-7	5,948	56·0	1,108
8-8	7,375	50·0	1,225
8-9	7,465	48·0	1,190
8-10	6,435	50·0	1,070
8-11	5,264	53·0	928
8-12	6,018	48·5	970
8-13	5,598	50·0	930
8-14	5,535	66·0	1,214
8-15	3,852	56·0	720
8-16	3,674	45·0	550

No automatic separation of slag and matte was made.

The slags did not carry more than 1·3 ounces per ton.

The charge was prepared in stalls, in thin alternating beds, so as to insure a more nearly perfect mixture of the ore and fluxes.

The charcoal was of mezquite wood and could stand well the crushing effect of the charge. Its price varied from $2.50 to $2.75 per 300 pounds.

Iron ore cost from $1.25 to $1.75 per cargo of 300 pounds.

Cupellation.—For the extraction of the silver from the base bullion and the sulphides from the lixiviation, no modern methods could be applied on account of the local conditions and because of the first expense, which the Company would not permit. Cupellation, however, is a very effective process, and the Mexicans ars quite experts in handling it. The loss in silver did not exceed 0·7 per cent. We used the English cupel. Dimensions: 46 x 59 inches.

The lining was made of a mixture of limestone and decomposed rhyolite, in the proportion of 100 of the former to 46 of the latter.

Its composition is as follows:

	Decomposed Rhyolite.	Limestone.
Si_2O_3	51·0	10·0
Al_2O_3	18·6	0·8
Fe_2O_3	15·4	3·4
Ca O	2·2	47·0
H_2O	8·1	1·8
CO_2	—	37·0

Each cupel necessitates 1,579 pounds of the above mixture, which was moistened very slightly and passed through a No. 4 mesh screen.

The tamping is done by proceeding from the center in the form of a spiral. The circular indentations should overlap in part. At Aduana the tamping was done on a great number of layers.

The cupel, once in place, is heated very slowly so as to avoid cracking, and towards the end, that is, after forty-eight hours, heated intensely and varnished with litharge, when it is ready for charge.

The sulphides of silver are incorporated in the lead bath with twice as much litharge. The base metals and foreign matter of the base bullion are carried away by the litharge and the skimmings. Some of the copper, however, remains until the last moment, and only comes out with the last litharge, which is very rich, and, as a rule, is revivified and treated in the cupellation.

Two tuyeres furnish from a small ventilator the blast at a pressure of 7 ounces per square inch.

The capacity of a cupel is 3,500 pounds. The duration of a cupel is forty days, if managed carefully.

Losses in silver	0·7 per cent.
Consumption of wood per twenty-four hours	$7 50
Labor, per twenty-four hours	9 00
Cost of cupellation per ounce is	013

As the mint of Alamos accepted bars of silver with 985 fineness, we never tried to pass 992; the average, though, was 990.

Our monthly production in fine silver could be increased considerably, since the construction of two more reverberatory furnaces was effected.

Mr. Dorion conceived the idea of the utilization of the bed of the river, which is dry most of the time, as a filter for all the waters coming from the reduction works. A mile from the reduction works a well was dug, and the waters accumulated there. An electric pump pumped the water back, and thus the concentration could go on almost all the year without interruption. These two facts ought to increase the production considerably, if everything is managed skillfully.

During the year 1896 the cost of 1 ounce of fine silver can be stated as follows:

		Per Cent.
Cost in mining	$0 391	or 36·0
Cost in milling	286	or 26·4
Cost in administrative expenses	075	6·9
Profit	333	30·7
	$1 085	100·0

THE FRANKLIN INSTITUTE.

Stated Meeting, September 21, 1898.

A NEW PROCESS OF COMBUSTION.

By Paul J. Schlicht,
Member of the Institute.

To the layman, combustion is a most perplexing and distressing problem. He seems to know by intuition that a large part of his coal-pile goes to waste up his furnace-chimney, and, while deploring the fact, is helpless against it. He has heard of the smoke-nuisance, and when he sees dense black clouds belching forth from countless chimneys he shakes his head and bemoans the terrible fuel losses. While his intuitive knowledge as to his house-furnace cannot be gainsaid by the expert, it is unfortunately defective when applied to that duskiness of the heavens produced by the thick carbon-laden breaths of factory-furnaces that defile the atmosphere of our manufacturing centres.

As a rule, the expert has given little thought or attention

to the stove and house-furnace, but he knows that those black out-breathings which to the layman are signs of such reckless waste are but of infinitesimal economic significance.

He can cite instances of evaporative performances that prove most satisfactory realizations of the calorific values of the fuels burned, and generally insists (at least such has been my experience) that in these well-designed plants substantial gains cannot be made by any improvements in combustion.

While this may be approximately true of some model plants where the most intelligent watchfulness and care are exercised and the fuel contains a high percentage of fixed carbon, it is not true when use is made of fuels whose com position is less favorable to the limitations of the ordinary process of combustion.

When the fuel contains too large a percentage of volatile matter the conversion of its energy into useful work ordinarily entails enormous losses. This is true more especially of those fuels that have hydrogen in excess of the quantity which will unite with their oxygen.

I am not aware that, in the industrial analyses of flue-gases, the losses due to the escape of combustible gases other than carbon-monoxide are taken into account. I know of instances of plants built in accordance with the best engineering practice where less than 40 per cent. efficiency has been realized in a clean boiler when such fuels have been used.

The stove and house-furnace and the industrial furnace are not in the same category.

In the former combustion is slow, in the latter generally rapid. Slow combustion in the stove and house-furnace is generally incomplete with the best fuels. Rapid combustion, except as to the volatile portions of fuels, is generally complete.

Incomplete and wasteful combustion in stoves and furnaces is due to insufficient and irregular air supply. In the industrial furnace an abundant air supply produces complete, even if in many instances, wasteful combustion with the best fuels and partially incomplete with others.

The fact that enormous losses occur in the burning of fuel in stoves and house-furnaces, and that in the best industrial plants the fuel energy is not adequately transformed into useful work, seems to me to offer abundant apology for my work in the field of combustion, which I will now endeavor to describe to you.

One of the objects of my process of combustion is to render available for useful work, in a simple manner, the greatest number of heat units in a given fuel, without material alteration of existing apparatus. It is especially with this phase of my invention that I desire mainly to occupy your attention.

The invention is based upon the fact, which I have discovered, that if a current of air is properly introduced into a chimney or flue through which hot products of combustion are escaping, the air current will flow in a direction contrary thereto, and, becoming heated in its contact therewith, will reach the sphere of combustion in a condition highly favorable to the union of its oxygen with all the combustible elements of the fuel.

In stoves, house-furnaces, and other slow-combustion apparatus, all of the air for combustion is supplied on the top of the bed of fuel. In industrial furnaces the desired rate of combustion determines the quantity of air to be admitted below the bed of fuel in addition to air supply on top.

In some instances the best results are obtained by closing, or nearly closing, the ash-pit door. In other instances, when a high rate of combustion is necessary, the resistance offered by the bed of fuel and the air pressure downward through the chimney or flue, so reduces the air pressure ordinarily exerted through the open ash-pit doors that no appreciably large air supply is furnished upward through the bed of fuel, but it is given a double air supply most favorable to high efficiencies.

In the ordinary process, combustion is most active over the grate bars, but its uniformity is constantly interfered with by the varying thickness of the bed of fuel and the gradual accumulation of ashes. In stoves and house-fur-

naces the losses from the escape of carbon-monoxide and other combustible gases up the chimney, in very large quantities, is the result of feeding the air for combustion upward under the grate bars, and through the bed of fuel. In industrial furnaces this upward draft generally results in the feeding of an excessive air supply, the losses due to which are known to those who have made a special study of the subject, and are now beginning to receive the attention they deserve by engineers generally. I will not refer to the breaking up of carbon-dioxide, about which much might be said.

The purpose of the house-furnace and heating stove is to maintain the temperature of rooms at a degree conducive to the comfort and health of their occupants. The purpose of the industrial furnace is generally to maintain a pressure of steam sufficient for power requirements.

An air supply adequate to thoroughly oxidize the combustible elements of the fuel would be inconsistent with the purpose of the heating stove and house-furnace, and would produce a great excess of heat, and require the burning up of a larger quantity of fuel than is now burned imperfectly to meet practical requirements. Moreover, to maintain fires it is necessary to shake down the ash daily so as to permit the air supply to reach the fuel. This produces, in mild weather, a temperature that is not conducive to the comfort or health of the occupants of rooms so heated.

By my process of combustion there is no solid and varying resistance to the air supply, as in the old process due to accumulations of ashes and varying thickness of fuel, but there is a constant supply of heated air that flows in contact with the combustion products, and which is regulated by the quantity of combustion products passing through the flue or chimney.

An evenness of temperature can at all times be maintained, labor is reduced, poisonous gases are converted into useful work, and the coal pile has been made often to last more than twice as long as ordinarily.

The feeding of air through the flue or chimney in regulated quantities on top of the bed of fuel in stoves and house-

furnaces by my process has secured some very remarkable results.

During mild weather the ashes have been allowed to accumulate for days, and a very small fire maintained on the surface thereof.

This has been done with a ten days' accumulation of ashes, an evenness of temperature and the burning of the fuel to clean ash with entire freedom from clinkers resulting therefrom.

In this process the combustion chamber is raised to a higher temperature than that attained in the ordinary process, and therefore when applied to hot-air furnaces previously incapable of furnishing warm air to all of the rooms of a house, the cold rooms have been successfully heated.

In addition to gains of from 25 per cent. to 50 per cent. in stoves and house-furnaces by the use of this invention, it has been found entirely practicable to use the smaller sizes of fuel, such as pea coal, instead of the more expensive furnace coal. As the calorific value of pea or any of the other sizes of small anthracite, when washed, is just as great as that of the larger sizes of coal, the burning of the former should give approximately as good results as the latter with my process, the saving in price of which should be added to the gain made by the burning of a smaller quantity of coal. Furthermore, the production of coal gas within and without the house is effectually prevented by this invention.

* * * * * * * * * *

I believe that the most common sources of waste in industrial furnaces when the fuel is high in fixed carbon, are those due to excessive air supply and to the non-transmission of a portion of the heat of the gases through the boiler plates, the rate of flow of the gases, being more rapid than the rate of transmission through such plates. I effectually prevent such wastes in plants favorable to the proper application of my invention, besides bringing back waste heat to the combustion chamber. When the fuel is high in volatile matter, the additional gains by my system are

very large. I have realized gains as high as 40 per cent. in well-designed plants burning such fuels.

This latter gain was made at a plant where evaporative tests of two weeks' duration were confirmed by months of subsequent use of the system.

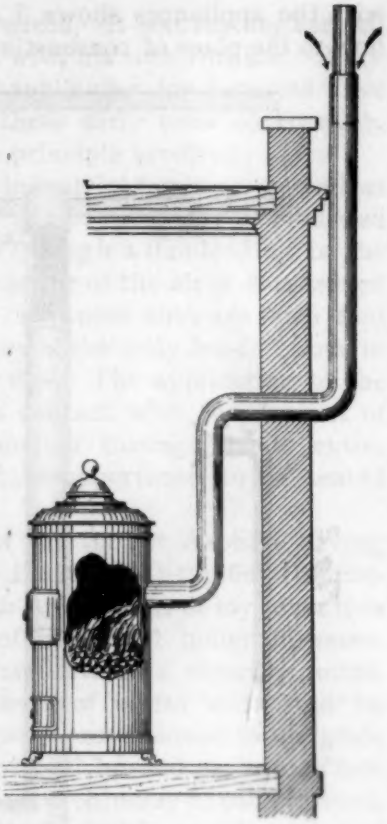
In industrial furnaces, where the draft has been insufficient to economically burn the smaller sizes of anthracite coals, I have realized large gains with my process in the burning of these cheaper fuels, burning them either alone or mixed with soft coal. I am well aware that with high chimneys and forced draft this can be done successfully, but I maintain that it can, in most cases, be done on a smaller investment and with a less deterioration of the boiler plant and greater economy by my system. Another great source of gain that has been realized with my process of combustion is the less frequent cleaning of boiler-furnace fires. At one large plant which had been run with the closest regard to economy, the services of two men were easily dispensed with.

Before describing my invention in detail, I desire to fortify myself by the testimony of others who have used my combustion process successfully, and who, when it was first presented to them, were skeptical, as you doubtless are, regarding the results I profess to be able to attain.*

The accompanying illustration shows a stove similar to the one with which I made experiments of different kinds to test the efficacy of my induced downward draft. I carefully sealed up every crack and joint with asbestos cement, so that the air supply could only come through the chimney. The length of the smoke pipe was about 25 feet, including the bend, and I was able to burn the coal so as to give an even heat many times longer than would be possible by the ordinary process. The coal was burned to an impalpable powder. It was a fairly good quality of anthracite coal, but burning it in the ordinary way produced clinkers. The appearance of the fire was different from that of ordinary

* Mr. Schlicht here read extracts from letters from users of his combustion process confirmatory of his claims to economy, evenness of temperature, etc.

fires, a peculiar pulsatory action being observable and a much greater heat produced by the small quantity of coal on the grate. The temperature of the escaping products of combustion was very low and there was no carbon-monoxide in the products. I proved to my own satisfaction with this stove that a very low rate of combustion could be maintained without the production of carbon-monoxide. Roughly the experiment indicated several times greater efficiency than shown with the old process.



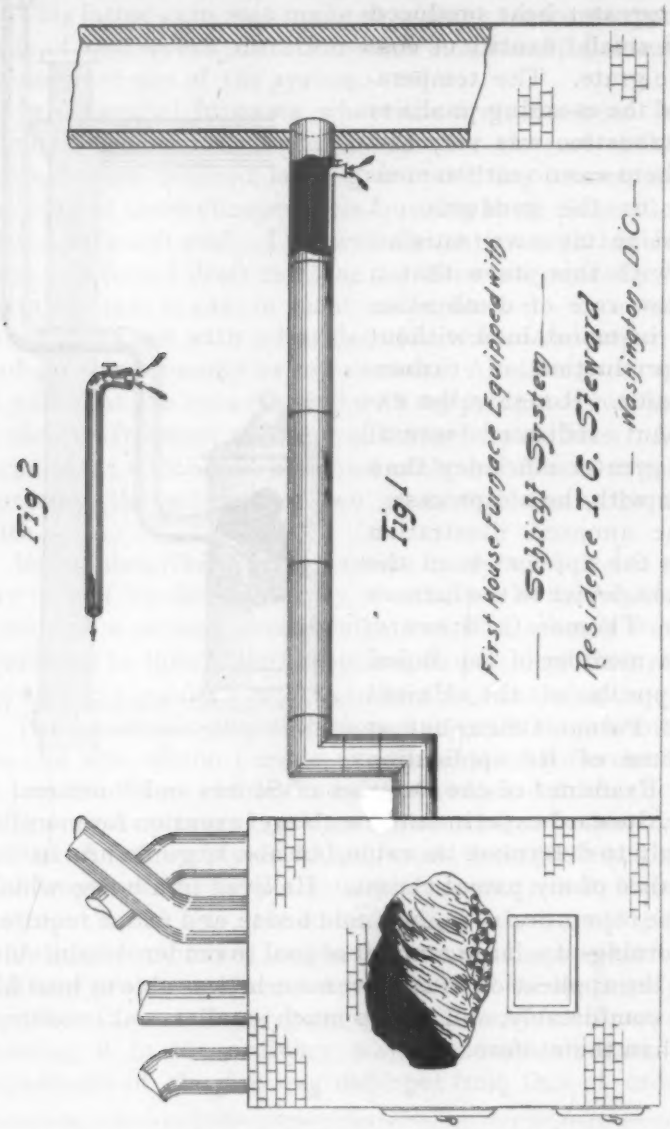
The annexed illustration shows the application of the Schlicht device to the furnace of Mr. Thomas G. Steward, now a member of the Board of Appeals of the United States Patent Office, but at the time of its application Chief Examiner of the Division of Stoves and Furnaces.

Mr. Steward experimented with my invention for months, not only to determine its value, but also to guide him in the allowance of my patent claims. He lived in a house which had the reputation of being a cold house, and which required the burning of a large amount of coal to render it habitable. Upon the application of my invention he was able to heat his house comfortably, and with a much smaller coal consumption than theretofore.

* * * *

When my application was first filed it was rejected on the ground of inoperativeness, the examiner denying that,

with the appliances shown, I could cause an air current to flow to the place of combustion. This fact I subsequently



proved by a practical demonstration in the basement of the Patent Office in the presence of the different examiners of

the division of stoves and furnaces. It was further verified by Mr. Steward's experiment with his own furnace. Since these early experiments, the appliances for furnaces have been greatly improved, but these early tests conclusively proved the correctness of the principle involved.

The air for combustion in industrial furnaces, as well as stoves and house-furnaces, as will be seen, may be admitted at the top of the chimney or through a flue leading to the same. The place for the admission of the air is determined by the conditions. In some instances they are such that the application to the chimney is the only feasible one, in others the application to the flue. The application to the top of the chimney secures contact with the current of escaping products of combustion throughout its entire length, giving the air abundant opportunity to be heated thereby.

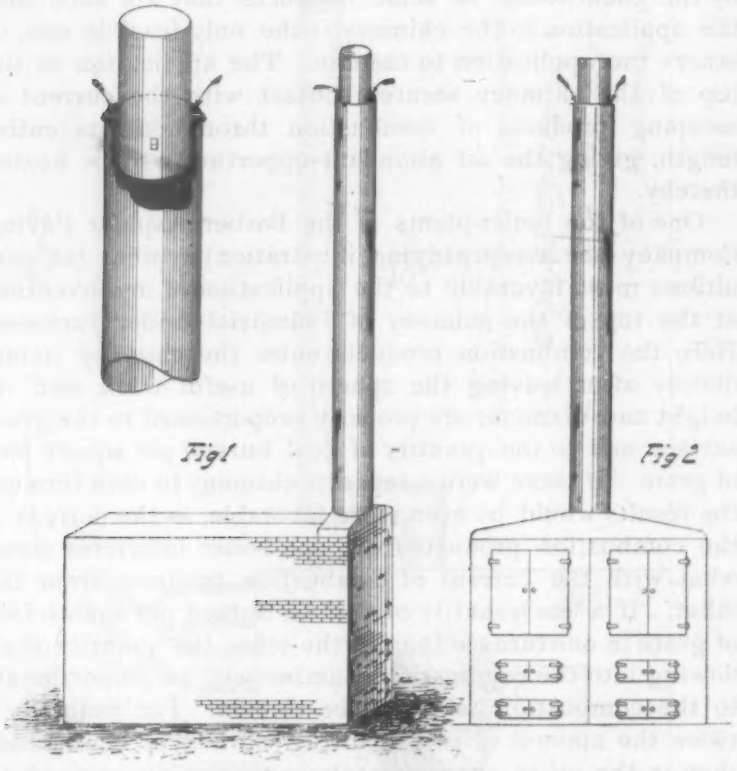
One of the boiler-plants of the Barber Asphalt Paving Company (see accompanying illustration) typifies the conditions most favorable to the application of my invention at the top of the chimney of industrial boiler furnaces. Here the combustion products enter the chimney immediately after leaving the sphere of useful work, and its height and diameter are properly proportioned to the grate surface and to the quantity of coal burned per square foot of grate. If there were a separate chimney to each furnace, the results would be even more favorable, as the current of the combustion products from one boiler interferes somewhat with the current of combustion products from the other. If a less quantity of coal be burned per square foot of grate in one furnace than in the other, the quantity of air flowing into the combustion chamber will be proportionate to the combustion taking place therein. For example, if twice the amount of coal is being burned in one furnace than in the other, approximately twice the quantity of air will automatically flow to the combustion chamber of that furnace.

These two boilers are return tubular. For a part of the day the plant is run below and for the other portion, far beyond its rated capacity. It is while burning the largest

amount of coal per square foot of grate surface that the largest economy is effected. Evaporative tests with these boilers show the following results with "Sonman" bituminous coal:

	Without Schlicht Process.	With Schlicht Process.
Pounds water from and at 212° per pound of coal	10·79	12·96 and 12·68
Horse-power developed	166	188 and 172

Fig. 3



A test made to determine the efficiency of process with reference to time required to melt 250,000 pounds of crude asphalt showed: without Schlicht process, 20 hours; with

Schlicht process, 17 hours, and requiring a consumption of 8¾ per cent. less coal.

The amount of work done at this plant was greatly in excess of that done in previous evaporative tests.

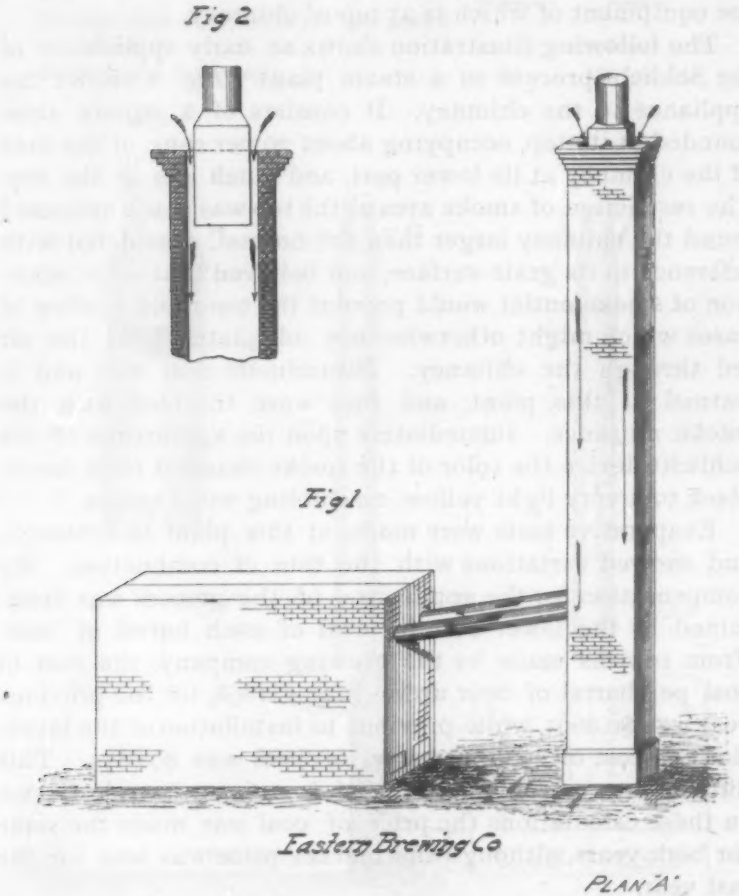
There are also Babcock & Wilcox's boilers at this plant, the equipment of which is at top of chimney.

The following illustration shows an early application of the Schlicht process to a steam plant. *Fig.* 2 shows the appliance in the chimney. It consists of a square tube rounded at its top, occupying about 70 per cent. of the area of the chimney at its lower part, and much less at the top. The restriction of smoke area at the top was made because I found the chimney larger than the normal, considered with reference to its grate surface, and believed that such reduction of smoke outlet would prevent the too rapid outflow of gases which might otherwise not adequately heat the air fed through the chimney. Bituminous coal was and is burned at this plant, and they were troubled with the smoke nuisance. Immediately upon the application of the Schlicht device the color of the smoke changed from dense-black to a very light yellow, resembling wood smoke. * * *

Evaporative tests were made at this plant (a brewery), and showed variations with the rate of combustion. My compensation for the application of the process was determined by the lower cost for coal of each barrel of beer. From returns made by the brewing company, the cost of coal per barrel of beer up to June 1, 1898, for the previous year was $0.0695, while previous to installation of the invention the cost of coal per barrel of beer was $0.0855. This difference represents a saving of $0.016 per barrel of beer. In these calculations the price of coal was made the same for both years, although the market price was less for the last year.

About this time the German Patent Office, doubting the statement in my application for a patent that I could cause air to flow down a chimney in contact with products of combustion escaping therefrom, requested me to furnish affidavits of reliable experts in corroboration of this fact. Accompanied by Professor Greenleaf, formerly of Columbia Col-

lege, and John J. Powers, I secured evidence of this fact in a very simple manner. Pieces of tissue paper were strung upon a string with a piece of wood fastened at its lower end. The string was let down the chimney close to its side and

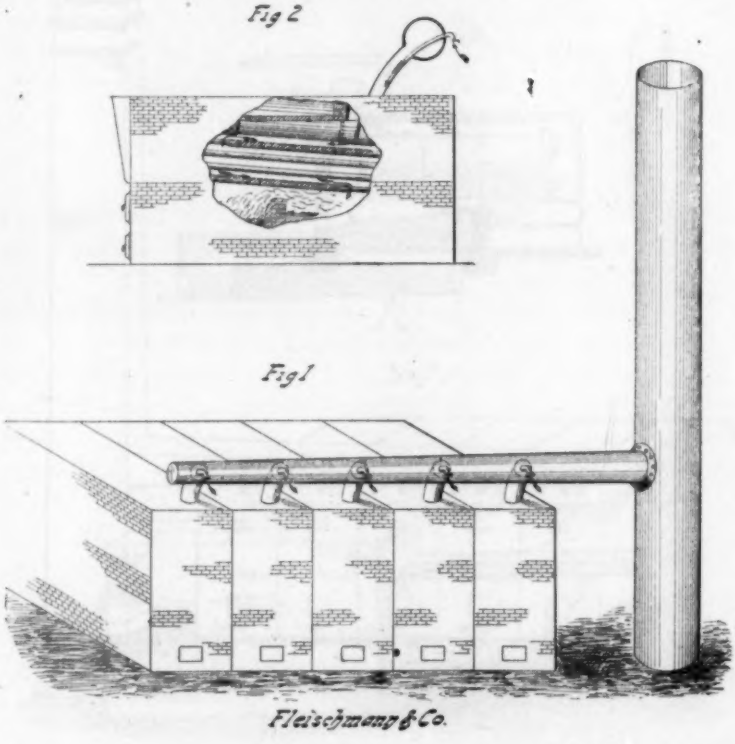


the papers strung upon it were drawn down in the manner that pieces of paper on a kite string are carried to the kite, known to boys as "telegraphing to the kite."

This plant was run for long periods with ash-pit doors shut, during which period combustion was intense. The

remark was made by the stoker that, "the draft was very strong."

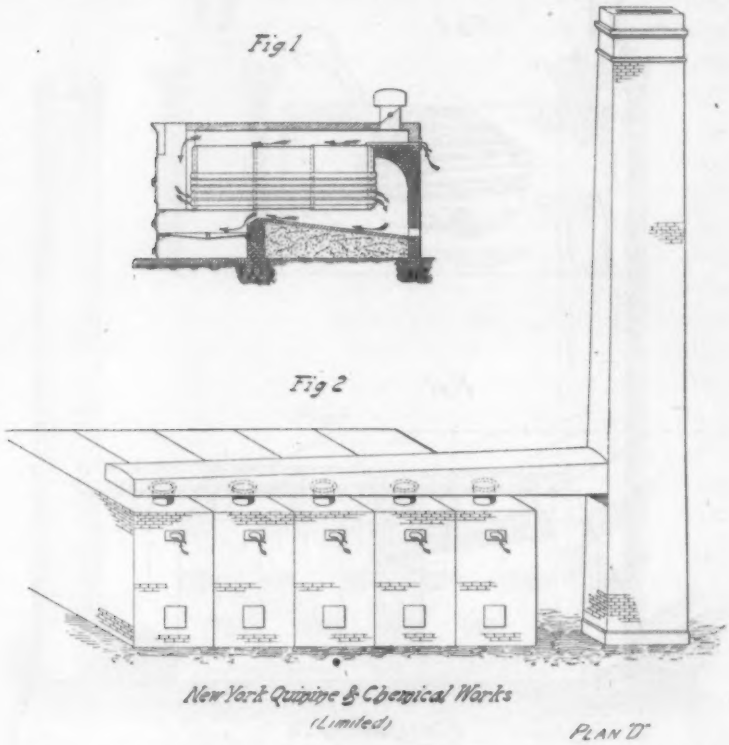
This illustration shows the application to the boiler plant of Fleischmann & Co.'s distillery at Blissville, Long Island. *Fig. 1* represents the entire plant with air-feed devices applied to the flue of each boiler. In a preliminary test on one boiler the heat generated with my process was greatly



in excess of the absorptive capacity of the boiler and consequently the ratio of grate surface to heating surface was reduced, and 15 per cent. gain made. Before this was done the products of combustion were of a temperature sufficiently high to melt the pyrometer placed in the flue to determine temperature of flue-gases. In order to determine to what extent the reduction of grate surface was responsi-

ble for the gain made the air-feed pipe was shut off and a test was made the old way which showed a lower evaporation, proving that the reduction of grate surface, while beneficial with the Schlicht process applied to a Heine boiler, was decidedly disadvantageous without it.

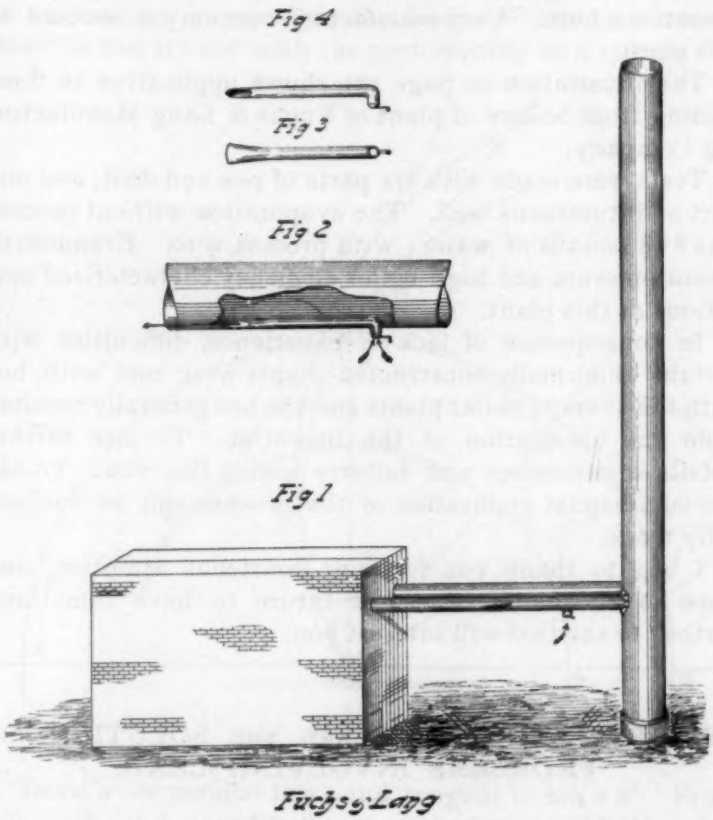
Mr. Jacob Blumer, the chemist and superintendent of the Blissville plant of Fleischmann & Co., carried on a great



number of careful experiments to determine the cost of a horse-power with different fuels and different boilers, under the direction of Mr. Charles Schlagenhaufer, Superintendent of Manufacturing for Fleischmann & Co., an engineer of great sagacity and practical experience. I am permitted, on the authority of the latter, to state that independently of the gains shown by official evaporative tests there are so many other indisputable evidences of benefit that he cannot but

give the process his unqualified approval. Reduced coal bills, less ashes and refuse, greater uniformity of steam pressure, reduction of smoke, increased power when desired, are among these evidences.

Using "Coledale" bituminous coal an evaporative test showed: without the Schlicht system, an evaporation of



11·08 pounds of water per pound of coal from and at 212°. (The rate of combustion was 14 pounds per square foot of grate per hour.) With Schlicht process, evaporation was 12·19. Capacity test showed 8 per cent. better results than builders ever secured.

The illustration on page 370 shows the application to each boiler of the New York Quinine and Chemical Works, Limited. The air is introduced to each boiler as shown in *Fig. 1*.

Inferior coal was previously tried without success. Good results were produced with my process. Steadier steam pressure and greater boiler efficiency characterize boiler operations here. Very satisfactory economy is secured at this plant.

The illustration on page 371 shows application to flues leading from boilers of plant of Fuchs & Lang Manufacturing Company.

Tests were made with six parts of pea and dust, and one part of bituminous coal. The evaporation without process was 8·08 pounds of water; with process, 9·10. Evenness of steam pressure and high boiler efficiency characterized operations at this plant.

In consequence of lack of experience, difficulties with certain abnormally constructed plants were met with, but with the average boiler plants success has generally resulted from the application of the invention. To cite further details of successes and failures would tire you.. To-day the commercial application of the process can be successfully made.

I beg to thank you for your courteous attention, and hope to be able in the near future to have something further to say that will interest you.

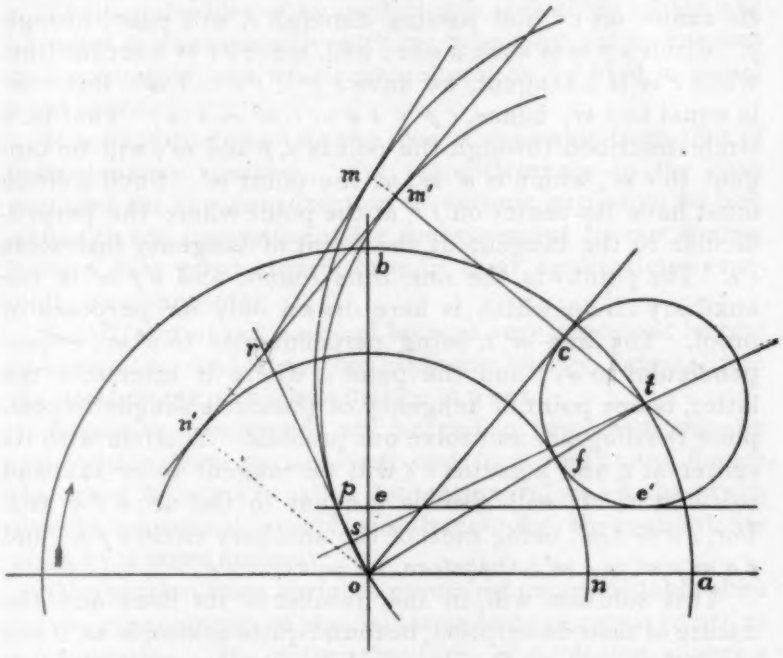
BILGRAM'S DIAGRAM AND THE SOLUTION OF PROBLEMS INVOLVING LEAD.

By Merrill Van G. Smith.

Apropos of Professor Fox's recent article on the Zeuner Diagram, in which allusion is made to the approximate solution, by Bilgram's method, of one of the fundamental problems involving lead, the following is given to show that the same can be solved by a simple and exact construction.

The problem, which is that given as Problem IV in Professor Spangler's treatise on valve-gears and as Problem 15 in Professor Fox's article, is: Given the point of cut-off, lead and port-opening, to find the angular advance, lap and eccentricity.

Draw *o a* and *o b* at right angles, and lay off *o c* to represent the position of the crank at cut-off. Draw *e e'* parallel to *o a*, making *o e* equal to the lead. With *o* as a center, describe the arc *n n'* with the port-opening as a radius.



Draw *n' m'* parallel to *o c* and tangent to arc *n n'*. From *o*, let fall *o p* perpendicular to *s t*, the bisector of the angle made by *o c* and *e e'*. With a center on *s t*, draw any secant circle, as *o p m*, passing through *o* and *p*. From *r*, the point where *o p*, prolonged, intersects *n' m'*, draw *r m* tangent to this secant circle. Lay off the distance *r m'*, on *n' m'*, equal to *r m*. Then, from *m'*, draw *m' t* perpendicular to *n' m'* and the point *t*, where this line intersects *s t*, will be the

center of a circle, which, with a radius equal to $c\ t$, will be tangent to $e\ e'$, $n\ n'$ and $o\ c$. And, joining the centers o and t, of the circles $n\ f\ n'$ and $c\ f\ e'$, we have $t\ o\ a$ as the angle of advance, $t\ f$ as the lap and $o\ t$ as the eccentricity.

The proof the construction, in short, is:

The line $n'\ m'$, being parallel to $o\ c$, and tangent to the arc $n\ n'$, is distant from $o\ c$ an amount equal to $o\ n' = c\ m' = o\ f =$ the port-opening. The line $o\ p$, let fall from o perpendicular to $s\ t$, the bisector of the angle made by $o\ c$ and $e\ e'$, is divided into equal parts, $o\ s$ and $s\ p$. Any circle having its center on $s\ t$, and passing through o, will pass through p. Circle $o\ p\ m$ is such a one; and, since $o\ r$ is a secant line, while $r\ m$ is a tangent, we have $r\ p \times r\ o = \overline{r\ m}^2$. But, $r\ m'$ is equal to $r\ m$; hence, $r\ p \times r\ o = \overline{r\ m}^2 = \overline{r\ m'}^2$. That is, a circle described through the points o, p and m', will be tangent to $r\ m'$, which is $n'\ m'$, at the point m'. Such a circle must have its center on $s\ t$, at the point where the perpendicular to the tangent at the point of tangency intersects $s\ t$. The point t is the one thus found, and $o\ p\ m'$ is the auxiliary circle, which is here drawn only for purposes of proof. The line $m'\ t$, being perpendicular to $n'\ m'$, is perpendicular to $o\ c$; and the point c, where it intersects the latter, is one point of tangency of the circle sought to complete the diagram and solve our problem. A circle with its center at t, and a radius $c\ t$ will be tangent to $o\ c$ at c, and to $e\ e'$ at e'. It will also be tangent to the arc $n\ f\ n'$ at f. For, $t\ o = t\ m'$, being radii of the auxiliary circle $o\ p\ m'$, and $f\ o = o\ n' = c\ m'$; therefore, $t\ f = t\ c = t\ e'$.

This solution will, in the number of its lines and the nature of their description, be found quite as simple as, if not somewhat more so than, the solution to the same problem given by either Professor Spangler or Professor Fox by means of Zeuner's diagram.

ENGINEERING LABORATORY, UNIVERSITY
OF PENNSYLVANIA, July 2, 1898.

CHEMICAL SECTION.

Stated Meeting, September 20, 1898.

HIGH EXPLOSIVES AND SMOKELESS POWDERS AND THEIR APPLICATIONS IN WARFARE.

By Hudson Maxim.

The popular idea of an explosive is something which will burn up instantaneously without requiring air to support its combustion, and which may, therefore, be fired in a confined space.

It is hard to dissociate the idea of explosion from that of instantaneous reaction. Yet the differences in the time required for the consumption of various explosive bodies, although too insignificant for measurement by our senses, have a very great significance in their applications, especially as gunpowder.

Small fractions of a second become very important factors in controlling and directing explosive energy, especially in the attainment of high ballistics in guns.

Explosive compounds are burned in two ways: one, by combustion from surfaces exposed to a consuming flame; the other, by what is called detonation, by which the explosive is consumed nearly simultaneously throughout its mass by a wave action.

Combustion from surfaces requiring an appreciable time for the consumption of the explosive body adapts it to use as a gunpowder. The detonative form of explosion adapts a body to shattering or disruptive purposes, and unfits it as a gunpowder. The latter are termed high explosives. However, the function of an explosive, whether as a combustive or a detonative compound, is very largely determined by its physical character, temperature, and the conditions of confinement under which it is fired.

By making an explosive compound dense and hard, its susceptibility to detonative influences is lessened, owing to

the increased work imposed upon the reaction in overcoming the force of cohesion. Similarly, the adulteration of an explosive body with another and non-explosive body lessens its susceptibility to detonative influences, owing to the energy required in breaking up the foreign body.

It is well-known that guncotton can be ignited in considerable quantity and burned quietly away without detonation. If, however, a sufficiently large mass be fired, the localization of heat and pressure upon the surface of the burning body, owing to the energy required to displace the products of combustion as fast as set free, will cause the whole mass to detonate. In this instance the heat and pressure of the products of combustion upon the surface of the burning explosive perform the function of a detonator or exploder, like fulminate of mercury.

The reason why fulminate of mercury is so powerful a self-detonative body is owing not only to the weakness of the chemical bond between the molecules of its constituents, but owing as well to the high specific gravity and density of its products of combustion and their confining or tamping influence.

Nitroglycerin, in small quantities, may be burned like an oil, and even fulminate of mercury may be burned in a vacuum without detonation. Nitrogelatin, the most powerful commercial high explosive known, may even be used as gunpowder in small quantities and under light confinement.

Fibrous guncotton, which consists of an infinite number of small tubes, whose walls, although of a dense colloid, are very thin, owes the facility with which it can be detonated, to the fine state of division of this colloid.

If guncotton be dissolved in acetone, poured on a plate of glass and dried, the hard and hornlike product, as is well-known, resists detonative influences. However, if reduced to a fine powder its susceptibility to detonation is restored, or if re-dissolved in acetone, and poured into water in a fine stream, a fluffy, fibrous material is formed, resembling very closely the original fibrous guncotton, and which will detonate with equal ease and violence.

Cordite, the smokeless powder at present used in England, consists of 58 per cent. nitroglycerin, combined with 38 per cent. guncotton, and 4 per cent. mineral jelly, which ingredients, if simply mixed together, or mechanically combined by absorbing the nitroglycerin in the guncotton, would make a very high-grade dynamite. In fact, it would be one of the most violent high explosives known. But in the manufacture of cordite the guncotton is dissolved in a volatile solvent, such as acetone, which is afterwards evaporated out, the nitroglycerin being added to the guncotton while the same is in solution, the resulting compound forming, when dry, an elastic, rubber-like body.

The nitroglycerin in cordite is still, however, only mechanically combined with the guncotton, and the guncotton colloid holds the nitroglycerin in its pores in the form of minute particles or drops, similar to the manner in which water is held in the pores of a sponge, except the guncotton sponge is very much denser and of very much finer texture, the density and tenacity of the sponge serving as a sufficient barrier to detonation to permit of the use of the compound as gunpowder.

Cannon powder is not a powder at all. The term "powder" in this application is a misnomer. Explosive compounds employed as propelling agents for throwing projectiles from guns, instead of being in pulverulent form, consist, on the contrary, of large grains or pieces of solid material, varying from a quarter of an inch to more than an inch and a half in thickness, and sometimes, as in the case of cordite, big sticks of explosive material are employed eighteen inches or more in length.

Originally, however, gunpowder was actually made in the form of a powder, being a loose, mechanical mixture of sulphur, saltpeter and charcoal, and which, although it did not detonate in the gun, was still completely consumed before the projectile had moved its length; consequently, charges could not be employed large enough to impart high velocities to projectiles without giving excessive initial pressure.

It was found that, by compressing the explosive mixture

into dense and hard cakes, and then breaking them up into grains, more time was required for combustion by reason of the flame being to some extent localized or confined to the surfaces of the grains, so that, instead of being all set free at once, the evolution of the gases was made to consume sufficient time to permit of the projectile being displaced enough to give room behind it for the reception of the gases of the explosion before the complete consumption of the charge. However, with such powders the pressures fell off rapidly because of the diminished burning area of the grains as combustion progressed.

A powder is smokeless which leaves no ash when burned, but is converted entirely into gases. A little more than half the products of combustion of common black powder consists of solid matter or ash, and it is this solid matter which makes the smoke.

If guncotton be dissolved in a suitable solvent, like acetone, and then dried, a very hard and hornlike substance is the result, which may be cut up into grains and used as gunpowder, but this substance is so hard and so dense that grains of it have to be made quite thin in order to secure its complete consumption in the gun, because it will not burn through a sufficient thickness before the projectile leaves the gun.

Owing to the fine granulation necessary to secure the complete consumption of a pure guncotton colloid, so much surface is presented per unit of weight as to preclude the use of sufficient charges to give requisite velocities without dangerous pressures. For this reason no pure guncotton powder, except in the form of the Maxim-Schupphaus multi-perforated grain, which will be explained further on, has yet been produced which has been successful in guns of more than four-inch caliber. Even in these guns, much higher ballistics are attained by multi-perforating the grains.

The addition of nitroglycerin to a guncotton colloid in its manufacture softens the material, and causes it to burn with greater rapidity, thus permitting of coarser granulation. However, in order to secure combustion through a

sufficient thickness of material to adapt it for use in guns of the largest caliber, nearly 60 per cent. of nitroglycerin is required. Such a compound is British cordite, and one too dangerously near being a detonative compound. Nevertheless, without multi-perforations there is no other method of securing the results.

Although a charge of powder in a gun is consumed with such rapidity as to appear to our senses to be instantaneous, still, it is far from being so. Although a grain of smokeless powder be consumed within one sixty-fifth of a second, still its combustion takes place entirely from the surface, and progresses with the most perfect regularity. Its combustion is similar to that of a piece of wood in the fire, only the combustion of the powder grain is infinitely more uniform.

When a rifle is placed to the shoulder and the trigger pulled, the time that elapses between the fall of the hammer and the flash at the muzzle is so brief that it appears to our senses to be perfectly instantaneous. Yet, during this time, the firing pin has moved forward and exploded the percussion cap, which, in turn, has fired the powder charge, and a certain period of time has been consumed in the combustion of the powder; the projectile has been started, at first slowly, and then forced along with accelerated velocity to the muzzle, and as the projectile moves away from the muzzle, the powder gases, rushing out at a much higher velocity than the projectile, impinge upon it, and are thrown outwards at right angles to the gun in the form of a disc, in exactly the same manner as though the projectile were held stationary in that position. Such, in spite of the evidence of our senses, is the relativity of velocities and time.

Probably no industry has, in its evolution, exacted more of the inventor than has the production of smokeless powder. Chemistry, physics, mechanics, mathematics and the science of gunnery, are all links in the chain upon which hangs success.

For about fifty years naval and military men have recognized the advantages of smokeless powder, providing such a compound could be practically produced. It was recog-

nized that the absence of smoke would give to the party using it a tremendous advantage over an enemy using black powder, owing to the difficulty that would be experienced in determining the direction or source of fire where smokeless powder should be employed; while, on the other hand, smoke-producing powder would not only cause the users of it to be readily located, but would, at the same time, serve to obscure their own vision.

Not until about 1888 had anything like a practical smokeless powder compound been produced. About that time, the French Government had, by a secret process, developed a smokeless powder for small arms, and which was used in the Lebel rifle, the substance being known as the Lebel powder. This compound is now known to have been simply a soluble variety of guncotton dissolved in a volatile solvent and then dried in thin films or sheets and cut up into small laminæ or squares.

The Lebel powder produced a great furore in Europe at the time, and the most wonderful claims were made for it. It was at that time that I began the investigation of the subject in England, returning soon afterwards to America, where I continued my work. A little later I engaged the services of Dr. Robert C. Schüpphaus, who was formerly connected with the American Xylonite Company. We joined our forces and our inventions, and have ever since been associated.

Up to that time, there had not been produced any smokeless powder for large guns, and even the then much-vaunted Lebel powder has since been replaced by another and superior compound.

The importance of solving the problem by the production of a successful smokeless cannon powder enlisted in the work many of the best chemists, mechanics and scientific men throughout the world, many of them being backed by limitless Government resources or by vast private capital.

Dr. Schüpphaus and myself entered the race for the production of a successful smokeless cannon powder with the field against us. Ours was a race against the world, and we were unfortunately handicapped by want of capital and the

difficulty of getting capitalists interested in a new and untried thing, and further handicapped by the dilatoriness, penuriousness and exacting methods of our own home Government.

In the face of all these difficulties and disadvantages, the Maxim-Schüpphaus smokeless cannon powder has been produced, and which has given the highest ballistic results ever known. All the most essential *desiderata* in a smokeless powder are its distinguishing features.

We discovered a new quality in nitro-cellulose, viz.: that by mixing a small percentage of soluble pyroxylin or gelatin guncotton with tri-nitro-cellulose, or high-grade guncotton, the mixture could be digested and rendered plastic, and could, under heat and pressure, be moulded into grains with very much less solvent, and that the grains so produced would shrink but little in drying, and would readily take and retain the shape of the forming die in all its geometrical details; whereas high-grade guncotton or tri-nitro-cellulose, if used alone, could not be moulded into similar grains without warping and cracking all to pieces in drying, while soluble guncotton is not only exceedingly difficult to work by itself, but presents to a great extent the difficulties encountered in the employment of tri-nitro-cellulose alone.

Our formula is an elastic one. We may either use no nitroglycerin at all, or may employ any percentage to meet the requirements of Ordnance Boards of different Governments; or we may replace nitroglycerin with an oxygen-bearing salt, such as nitrate of barium. But we prefer to employ, and recommend the use of, from 10 to 25 per cent. of nitroglycerin. A percentage so small has no disadvantages whatever, and has many advantages above a pure guncotton compound, or one containing an oxygen-bearing salt. Nitroglycerin is a compound that has been very widely misunderstood, and it is not generally known that pure nitroglycerin is even more stable, if anything, than pure guncotton, and that it will stand a higher heat test.

In the report of the Chief of Ordnance of the United States Army for 1896, page 197, after dwelling at length upon the advantages of progressive combustion, due to multi-

perforated grains, it is broadly stated that, "all things considered, the perforated cylinder in the Maxim-Schüpphaus powder appears to be the most suitable form for the colloidal smokeless powder."

It is obvious that a powder which presents a smaller initial burning area than another, and whose area increases, instead of diminishing, as combustion progresses, must be subject to enormously less variations in ballistics than a powder which presents the maximum area to the ignition flame and burns with a constantly diminishing area.

The Maxim-Schüpphaus smokeless powder, when compared with cordite, pound for pound, offers about one-fourth to one-fifth of the initial combustion area; and when compared with ballistite or cubical powders, it offers, pound for pound, less than one sixth of the initial combustion area. Therefore, when equal charges are fired, under like conditions, the Maxim-Schüpphaus powder will give at most, not more than between one fourth to one-fifth the variation in initial pressures that cordite gives. The same holds true for velocities, and the results of firing of our powder substantiate this claim.

One of the best and most comprehensive articles ever written on the Maxim-Schüpphaus smokeless powder appeared as an editorial in London *Engineering*, of August 20, 1897. The editor says:

"The distinguishing feature of the gunpowder invented by Mr. Hudson Maxim and Dr. Schüpphaus is its form. It has other characteristics of great value and originality, but these are only rendered possible by the peculiar shape in which the powder is moulded, and are, therefore, in a sense, subsidiary. . . . Whatever merit there may be in hyperbolic curves in a steam engine, there is none in a gun, for there the object aimed at is to impress the greatest possible amount of energy on the projectile with the least strain on the weapon. Evidently, this can best be done by a pressure sustained uniformly from breech to muzzle, such as would be represented by a rectangular diagram. The maximum pressure and the average pressure then become identical, and for any given ballistic result the maximum pressure is

greatly reduced below what it would be if there were sensible expansion of the gases in the bore.

"The result is sought to be attained in the Maxim-Schüpphaus powder, by giving to each grain such a configuration that the rate of burning shall keep pace with the motion of the projectile, and still maintain the space behind it filled with gases at a fairly constant pressure.

"If gunpowder grains be in the form of spheres or cubes, the rate of combustion is greatest at ignition, and gradually decreases as the grains diminish in size, while, on the other hand, the speed of the projectile through the bore rapidly increases. Hence, the pressure of the gases is not maintained. The ideal condition is that each grain shall, at the moment of ignition, present sufficient surface to combustion to give the required pressure, and that this surface shall rapidly increase so as to ensure more and more vigorous combustion."

The Maxim-Schüpphaus torpedo powder, that is to say, the grain I propose to employ for throwing high explosives from ordnance, is a cylinder six diameters long, and pierced longitudinally with nineteen angular perforations. The perforations are so shaped and so arranged with respect to one another, as to effect the complete consumption of the powder grain simultaneously with the intersection of the perforations with one another. In other words, when the perforations shall become so enlarged by interior combustion that they become tangent, the grain will be totally consumed.

The exterior of the grain is coated with a non-combustible substance, which, although consumed before the projectile leaves the gun, and also with the absence of smoke, still serves to confine the combustion nearly wholly within the perforations.

The torpedo powder grain, as already stated, will only present one-fifth the initial area to the flame of ignition that is presented by cordite, and about one-sixth of that presented by ballistite. Consequently, under like conditions of confinement, there will be only one-fifth the initial pressure for the same charge, and possible variations in velocities and pressures can be only one-fifth as great.

Now, therefore, if we employ a projectile of twice the weight and with the same area of base as that now employed with cordite, with a pressure of 35,000 pounds to the square inch, we shall still have less than half the pressure, and half the variations in pressures and velocities.

The key to a successful system of throwing high explosives from ordnance rests in the powder charge, or rather, upon the character of the powder grain. Second in import ance is the fuse; the third, the form of shell, and the fourth the high explosive to be thrown.

It is popularly supposed that the most essential requisite to a successful system of throwing high explosives from ordnance is to get them out of the gun gently—that high explosives of all kinds are very ticklish, and have to be handled with the utmost caution, and that the chief thing to be considered in the projection of high explosives from ordnance is the danger of their premature explosion in the gun, due to the shock of acceleration.

But this is not the case. In fact, nothing could be farther from the truth than such conclusions, for there are many high explosives as powerful as No. 1 dynamite, which may be handled and knocked about without any caution whatever, and which not only cannot be ignited when fire is applied to them, but which may be stirred up with a red-hot poker without any danger, or be fired into with shells from quick-firing guns without being exploded.

Such explosives may be thrown from ordnance at the same velocity with which ordinary shot and shell are now thrown from high power guns, and without the least danger from the shock of acceleration in the gun.

It is not generally known, but it is, nevertheless, a fact, that some of the most powerful of high explosives, such, for example, as wet guncotton, picric acid, known also under the names of lyddite, emmensite and melinite, are already successfully thrown from high power guns at service velocities.

A compound of picric acid and nitro-naphthalin, together with an admixture of nitrate of ammonia, is one such explosive compound. Picric acid, pure and simple, however, is

as powerful, volume for volume, as No. 1 dynamite, and it is, at the same time, wholly insensitive to any shock of acceleration to which it may be subjected in the gun.

Wet compressed guncotton may be fired from a gun at service velocities, and even exposed without any covering or protection whatever, to the white-hot gases of the propelling charge, a portion only of the wet guncotton being burned under the high heat of the powder gases.

An aerial torpedo filled with wet compressed guncotton would not be detonated by a quick-firing gun shell loaded with black gunpowder, penetrating it and exploding within the mass of wet guncotton.

Now, as it is the length of column of explosive in a shell which endangers it from the shock of setback or acceleration, we may increase the size of the projectile in cross-section indefinitely, to provide greater space for explosive without adding in the least to danger from shock in the gun.

In order to arrive at a correct understanding of what may be accomplished by this system of throwing high explosives from ordnance, let us take the present 12-inch sea-coast rifle as a basis for our calculations. This gun weighs 52 tons, and throws a projectile weighing, loaded 1,000 pounds, at a maximum velocity of 2,250 feet per second on a pressure of 35,000 pounds to the square inch, with a powder charge of 250 pounds Maxim-Schüpphaus smokeless powder, grains 3 diameters long, and having seven perforations.

The bursting charge of the 12-inch projectile is only 37 pounds of black rifle powder.

Now in place of the above 12-inch sea-coast rifle throwing a 1,000-pound steel shell filled with only 37 pounds of black powder, a torpedo gun could be constructed which would have the same weight and which would cost the same, both for the gun and for mounting, as the 12-inch gun, but which would have a caliber of 24 inches, and which, with the same factor of safety that the 12-inch gun stands 35,000 pounds to the square inch would sustain a working pressure of 12,000 pounds at the breech and 10,000 pounds at the muzzle.

The torpedo gun would have practically the same outside dimensions as the 12-inch gun for the rear half of its length, the diameter being a little larger forward.

Now, suppose we consider both guns to be of equal length, and the length of travel of the shot the same, and let us estimate in the 12-inch gun the working pressure throughout its length to average 22,000 pounds from breech to muzzle, we have against this in the torpedo gun an average working pressure from breech to muzzle of 11,000 pounds, just one-half the average pressure of the 12-inch gun.

But the base of the projectile in the 24-inch gun is four times as great as that in the 12-inch gun. Consequently, we have a pressure of 11,000 pounds exerted through the same distance and over an area four times as great. Hence, the torpedo projectile is thrown from the gun with twice the muzzle energy as the 12-inch shell. This enables us to throw a projectile of twice the weight as the 12-inch shell, or weighing 1 ton, at the same velocity as the present 12-inch shell is thrown, and the additional ½ ton of weight may be high explosive.

In other words, the torpedo projectile would consist of ½ ton of steel and ½ ton of high explosive, and we have, therefore, without any sacrifice of velocity, ½ ton of steel and ½ ton of explosive, in the place of 963 pounds of steel and 37 pounds of black rifle powder.

The high explosive which would be thrown would, pound for pound, be at least four times as powerful as black powder. This is a very low estimate. Consequently, the bursting charge thrown in the torpedo shell would be equal to more than 2 tons of black powder, and equal in force to the combined bursting charges of more than 100 12-inch shells.

[*To be concluded.*]

CORRESPONDENCE.

SCIENCE IN THE PUBLIC SCHOOLS.

Within less than a generation the scientific leaven has been working rapidly among educational authorities. The high school of to-day is equipped with apparatus and laboratories such as the best technical institution of thirty years ago did not possess. In our lower schools the maps are better than formerly, and a good modern geography gives information that ten years ago could not have been gathered except at a far greater cost. Of course, in this age, as in all its predecessors, a lazy or stupid pupil may go through school, and emerge therefrom with an amount of ignorance suggestive of the darkness of Egypt. A bright pupil, however, has advantages, such as no former era could have presented. Facts unknown to the investigators of our childhood, discoveries unmade until a recent period, observations of the latest date help a lad who has a scientific turn of mind to develop his faculties.

This improvement has been, in no small degree, brought about by the action of scientific institutions. Scientific investigation of some kind has always been in progress. In the English-speaking world it was quickened to a remarkable degree by the philosophers of Charles II's time, and the next century saw Franklin, Rittenhouse, Jefferson, and a host of other keen-witted Americans making experiments with almost boyish delight. Colleges and universities were for a long time ruled by an almost exclusively classical spirit, and scientific institutions grew up to give opportunities to men who wished to study hydraulics rather than Homer, and drainage in place of Demosthenes. For many years, such bodies were as far distant from the common school as from the classical academy. Public education was fought by many citizens and on many grounds; country trustees often favored the teacher who would accept the lowest salary; and the idea of giving even the barest kind of scientific training to the masses would have encountered a determined resistance. Men still under forty can remember how strong and persistent was the opposition to scientific teaching.

Year after year, the Franklin Institute and bodies of like character kept the even tenor of their way. Quietly and modestly, but steadily and effectively they did their work. Two generations ago intelligent men knew that there was a place in Philadelphia where one could obtain knowledge about meteorology, where scientific books unknown to the ordinary library might be found. Men who were fond of electricity, or who liked to know what was being done at the great iron works, or who wished to know something of the latest achievements in engineering could find congenial spirits at the Franklin Institute. As the wits and poets of old London flocked to the coffee-houses, so the men who liked to investigate and compare the results of their labors had what might be called their informal scientific clubs. Many a Philadelphian gained his knowledge of the growth of manufactures from the Franklin Institute exhibitions. Many a boy, sent to its drawing-school, grew interested in the long shelves of books very different from the dime novel, and in the apparatus which stimulated a desire to know more and more of the

achievements of human industry. To consult a dozen volumes of Patent-Office reports, or even to see half a hundred industrial publications is an experience to him who passes through it for the first time.

Every winter for many years the Franklin Institute has been scattering the seeds of applied science through the community. Few indeed are the subjects that have not been treated in some of its courses. Some of the papers read within its walls have dealt with matters so abstruse as to be beyond the grasp of all but the inner circle of specialists. Some have been of general interest. Quite a number have been within the comprehension of boys within their teens, and even small children have not been neglected. Writers for the technical press, and editors of the scientific columns in the dailies have been, directly or indirectly, indebted to this energetic, though unostentatious body for many facts and suggestions. It would be absurd to limit the influence of a university to a roll of its alumni, or the influence of a library to those on its list of membership. With equal justice it may be said that the Franklin Institute has been a mental force to many who have never connected themselves with it, or in any way acknowledged their obligations. Continuous effort tells, and the Institute's unbroken record of thorough-going scientific work is one of the proudest traditions of a proud old city.

Without any desire to withhold the meed of praise from any of the worthy institutions which, on both sides of the Atlantic, have held up the torch of science, we have spoken in particular of that body which so many manufacturers, engineers and inventors regard as their Alma Mater. It is not too much to claim that scientific bodies, of which the Institute is a type, have prepared the way for the text-books and apparatus of the modern public school.

ROLAND RINGWALT.

NOTES AND COMMENTS.

COMPARATIVE ECONOMY OF LOCOMOTIVE SERVICE ON ENGLISH AND AMERICAN RAILWAYS.

There has been an almost endless amount of controversy in the English and American engineering journals respecting the relative merits of the very distinct types of locomotive engines which characterize the railway practice of the two countries. The American engine is an evolution along mechanical lines dictated by the conditions of American service, which over a great portion of the United States are to-day even radically different from those prevailing in England and in Europe generally, and it is particularly significant that in the only country of Europe where the conditions approximate to those of America—namely, in Russia—the American type of locomotive is very generally in use.

On the score of performance as measured by fuel consumption, there it must be admitted that English locomotive practice is a long way ahead of the American. The inference might seem justified that this fact furnished conclusive evidence of the mechanical superiority of the British loco-

motive. As a matter of fact it is due to the laxity and general inefficiency of American methods of superintendence. Not that the needful knowledge and engineering skill is wanting among the Superintendents of Motive Power of our leading railroads and their assistants, but rather because this great comparative inferiority in our locomotive practice is only just now getting to be generally known and admitted, and a reform which must involve a general change in the methods of the men in the locomotive cab—the engine drivers and their firemen—is difficult to inaugurate. It is there, however, that the source of the comparative inefficiency of American locomotive practice has been definitely located. The fault lies in the careless, inefficient and wasteful method of firing almost universally in vogue in the locomotive engines of the United States.

The English railway superintendents, a generation ago began investigating to find the cause of the wide variations in the coal consumption of their engines performing the same service. They found that economy of coal depended on the method of firing. The wasteful way was the easy one of dumping the coal into the furnace without regard to where it was needed; the economical way was to distribute it evenly over the grate, selecting the four corners and the sides in preference and covering the centre of the fire-beds somewhat thinner than the other parts. The English superintendents were quick to see the importance of having their engines properly fired, and by the general adoption of stringent rules to govern the engine drivers by making them responsible for the quality of the work of their firemen, and of the policy of giving premiums to the engine drivers whose engines showed the most economical coal consumption, the evil of wastefulness was speedily checked and much greater efficiency was obtained.

The editor of *Cassier's Magazine* has endeavored to ascertain approximately how great the saving of fuel has been on the English locomotives since the practice of hollow firing—as the reformed method is called—has become finally established. He quotes from Clark's great work on "Locomotive Engineering" first issued in 1860, wherein the rule is laid down that "the coal consumption of an ordinary passenger train might be reckoned at 14 pounds of coal per mile for the engine and tender, and 7 pounds per mile for each passenger coach." The average weight of a passenger train in those days may be taken as 100 tons, which with the above figures would mean a consumption of 49 pounds of coal per mile

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Writing in 1885, twenty-five years later, the same careful author revises his figures substantially. They make an instructive comparison with those given above, for the reason that the marked difference between them may be attributed in a large measure to the substantial reform inaugurated, during that interval, in the methods of firing the locomotives on the British railways. Thus: A typical English passenger train, the express between Manchester and Derby, weighing, engine, tender and coaches, 225 tons, was hauled at 50 miles per hour, with the expenditure of 28 pounds of coal per mile. On the Great Northern, a fast express hauled a 224 ton train (at a speed of 50 to 53 miles per hour) with 25¼ pounds of coal per hour. A London and Northwestern train hauled a gross load of 293 tons at 45 miles per hour, with 26⅛

pounds of coal to the mile. As compared with those of 1860, these figures represent an actual saving of one-half the coal consumption per train-mile—certainly an impressive lesson upon the importance of looking after the men who run the engines.

The value of this chapter from English railway history lies, as Captain Bunsby says, "in the application of it," and if it be applied to American practice, a discrepancy appears that is too great to be accounted for on any other supposition save that the great and crying evil on our railways is wastefulness of the grossest kind in the use of coal and in the firing of locomotives. Just how great this wastefulness is, and how urgent the need of a radical reform, will appear from the following quotation from *Cassier's* bearing on American practice: "Now, while the engines and trains described by Clark are running to-day, it is safe to say that no engine in the United States, doing similar work, approach them in economy of coal consumption. Indeed, there is positive knowledge of one well-known fast passenger train on one of the routes between New York and Chicago, with a gross weight not exceeding 275 long tons, where the coal consumption averages 75 pounds per mile. The fact, however, that such a comparatively large coal consumption excites no special comment, and that no extraordinary effort is made to reduce it, justifies the inference that it is not considered remarkable."

It is simply inconceivable that this striking difference between the economic performance of the English and American locomotive is due to mechanical superiority in design and construction in the former, for the American locomotive is sold all over the world in competition with those of English and European builders. Nor can it be accounted for by the general inferiority of American coals as compared with the Welsh stone coal, since, on the most liberal allowance, this should not affect comparative results by more than 10 or 15 per cent., while the difference to be bridged over is about 300 per cent. Perhaps, as *Cassier's* editor somewhat sarcastically remarks, "the unfortunate fireman who has to shovel in 75 pounds of coal to the mile has no time to do more than dump it in at the fire-box door."

Railroad engineering management in this country of late years has undergone a great change for the better, and especially in the case of the great trunk lines, will compare favorably with the best of other countries; but it is evident, from what has been said, that there is room for more intelligent supervision in this one important point. W.

LIQUID HYDROGEN.

The advances that have lately been made in the improvement of the mechanical details of apparatus, have been so substantial that the liquefaction of air—until lately a most difficult and costly operation—has become so common that it has ceased to be a novelty. The English chemist, Dewar, in 1893, first drew attention to the subject by his remarkable experiments with the material at the Royal Institution in London. In these demonstrations he was enabled to produce only minute quantities of liquefied air with infinite difficulty, and at a cost which is said to have been at the rate of $2,500 for a quantity not exceeding a quart.

Since then, Linde, in Germany, and Tripler, in America, by improved compression apparatus, have shown that liquid air may be produced continuously and have supplied the product in large quantities, comparatively speaking, and at a cost of not exceeding, it is said, $1 per pound.

Tripler's work in this field has recently attracted much public interest, from the fact that he has supplied liquid air in quantities of from 5 to 10 gallons for lecture demonstrations before various learned societies.

One of these occasions was some months ago, at the Franklin Institute, where something like 8 gallons of liquid air were used, which had been shipped from New York in vessels resembling large milk cans with no other precautions than placing the vessel containing the liquid within another, the space between the two being lined with felt.

Hydrogen, however, has, until quite recently, apparently successfully defied all attempts to liquefy it. The claim has indeed been made by certain experimenters that a momentary mist within a glass tube indicated the incipient liquefaction of the gas, but these observations have been of so equivocal a nature that they have been accepted by scientific men with reservation.

At last, however, Professor Dewar has unquestionably accomplished this unique scientific feat, and has exhibited the liquid to Lord Rayleigh.

The successful experiment was made in the laboratory of the Royal Institution—the theatre of so many scientific triumphs at the hands of Humphrey Davy, Faraday and Tyndall—where Professor Dewar, according to the authority of the London *Times*, "actually produced the liquefied gas to the amount of half a wineglassful in five minutes by a process which would equally have produced a pailful had the requisite supply of pure hydrogen been forthcoming."

With no present or prospective practical usefulness attached to this achievement, it is not only of surpassing scientific interest, but also of great scientific importance, since it places at the service of investigators a means of commanding much lower temperatures—much greater cold—than it has hitherto been possible to attain, and scientific investigation has been compelled to stop far short of the limit of cold which liquid hydrogen can be made to yield.

In commenting on the properties of liquid hydrogen, the *Times* calls attention to the fact that the boiling point may be placed about 30° to 35° of absolute temperature; that is to say, about 240° below zero on the Centigrade scale. The following experiment is described to afford some conception of the degree of cold attained, viz.: If a tube closed at the lower end be immersed in the liquid hydrogen, it is almost instantly filled with solid air. The density of the liquid hydrogen is slightly more than half that of water.

One of the noteworthy things accomplished by Professor Dewar with this liquid, was the liquefaction of the rare gas helium which had hitherto resisted all attempts to effect its liquefaction. The boiling point of helium appears to lie very near to that of hydrogen itself.

The successful liquefaction of these two elements leaves nothing further to be done in this direction. There are no longer any known gases that remain in the category of incondensables, or permanent gases, as it was once the convenient mode of describing them.

It may be said in conclusion of the subject, that nothing now stands in the

way of the production of the liquid hydrogen in any desired quantity except the obstacle of its cost. This will always remain considerably higher than that of liquid air, because of the original cost of making hydrogen gas, but mainly because of the much greater difficulties attending its liquefaction. It will undoubtedly prove a valuable agent in the hands of physical and chemical investigators in the prosecution of researches that promise to add substantially to our knowledge of the ultimate constitution of matter. We can now reach down to within 30° of the absolute zero, where all matter is believed to be inert, dead. W.

POWER FROM BLAST FURNACE GAS.

Engineers on both sides of the Atlantic continue to discuss with interest the possibilities arising from the utilization of the waste gases of the blast furnaces. From the results of experimental trials that have been made of the method, there would appear to be no longer any question as to the practical utility of turning to useful account a large amount of power that is now wasted. An instructive example of the present state of this interesting problem is afforded by the results gained in the practical operation of a blast furnace power gas plant at one of the largest steel works in Belgium. At these works, after a continuous operation of a year, the conclusion was found to be warranted that a gas engine with such trifling modifications as are required to adapt it to the nature of the gas, could be operated with the waste furnace gas without serious injury.

The details of this test, embracing all the conditions of the experiment, are very lucidly set forth by Professor Hubert, under whose direction they were made. Some of the more important of the results of his observations are taken from an abstract of them in *Engineering Magazine*.

He finds that for every ton of pig iron there are also produced about 5,750 kilograms of gas, equivalent to about 4,300 cubic meters. A blast furnace producing 100 tons of iron per day, therefore, will produce about 18,000 cubic meters of gas per hour. Of this quantity, about one-half will be used in the hot-blast stoves, leaving about 9,000 cubic meters available for power purposes. He estimates, from the results of his observations, that the utilization of this 9,000 cubic meters in the gas engine should realize 3,000 horse-power, as the value of the gas from a 100-ton furnace, which is from three to ten times the power hitherto produced by burning the gas under steam boilers. In actual practice, about 1,800 horse-power was realized, of which only 400 horse-power was required for the blowing engines, leaving 1,400 horse-power available for other uses, and which represents so much clear gain.

It is argued that with the progress now being made in the construction of large gas engines, it will soon be practicable to drive blowing engines with gas motive power cylinders, thus enabling the present expensive steam-power plant to be dispensed with, the gas engines replacing the steam engines.

An extremely interesting phase of the argument presented in favor of the innovation is best stated in the words of *Engineering Magazine*, as follows: "When, as is now frequently the case, the blast furnaces form part of a general iron and steel works, in which large quantities of power are required for

rolling mills, forges, machine shops, etc., the power produced by the gases in excess of the furnace requirements is directly available for the other mechanical operations, thus enabling such plants to compete, so far as power cost is concerned, with the great hydraulic power installations which depend on natural sources of energy.

"The matter seems to be passing well out of the hands of the investigators into those of the constructing engineers. It is now the turn of the engine builders to produce large gas engines, especially adapted for use with lean gas, and suited for continuous heavy duty, and the part of energetic iron masters to take active steps to introduce the new system. Already, it is reported, a blowing engine to be operated by gas power is being designed for the Cockerill Company, and others should not be slow to follow."

From all that has been said above, it seems safe to conclude that the difficult pioneer work involved in the careful study of the conditions of the problem has been accomplished with results which should prove of the highest importance. W.

HOW SHOULD BOILER-HEATING SURFACES BE CALCULATED.

In a paper lately presented to the American Society of Mechanical Engineers, Mr. C. W. Baker questions the correctness of the usual practice of computing the horse-power of steam boilers from the heating surface. He affirms that by the method usually followed, there results an error of from 7 to 17 per cent., which, he says, is due to the practice of taking the surface in contact with the water, instead of that in contact with the fire gases, as the heating surface. Where these surfaces are flat, there will be no difference between one side and the other, but the boiler-heating surface is made up largely of tubes, and in these there is a difference of 17 per cent. between the interior and exterior surface in the case of a 1-inch tube, and of 7 per cent. in the case of a 4-inch tube.

The error to which Mr. Baker calls attention lies in the failure to appreciate the fact that the heating surface of the boiler, on which its steaming capacity depends, is the actual surface exposed to the fire or fire gases. With clean metal, the actual difference of temperature between the two sides of a boiler plate (or tube) is never more than 1° F., and Lord Kelvin has observed that for all practical purposes, we may consider that the heating surfaces of boilers conduct heat as though they were no thicker than paper.

It follows from the foregoing observations that the temperature of the heating surfaces of steam boilers is that of the wet side and not that of the fire side of the plate (or tube).

Although this fact is common knowledge among engineers, Mr. Baker claims that it has been generally overlooked by engineers and writers on engineering subjects, who have not insisted as they should that the fire side of boiler tubes should be that from which heating surface should be computed.

He illustrates his argument by the statement that if the fire side of the tubes be increased by forming ribs upon it —as is the case with the Serve tube— the steaming capacity of the boiler is thereby increased; but no such increase of steaming capacity will result from the placing of ribs on the wet side of the tubes.

Mr. Baker further makes the interesting statement that a thin coating of scale on the wet side of a boiler plate affects the steaming capacity less than a furring of soot on the fire side, which will be something of a surprise to most engineers. Another deduction of the author is that circulation of water in a steam boiler is of much less consequence than is generally supposed in its relation to efficiency. Good circulation is desirable because of its influence in assuring the equal heating of all parts of the structure, and hereby preventing undue strains in certain parts, but in Mr. Baker's judgment, it can have no effect on economy or efficiency.

The points made by the author seem to be well founded, and should receive the serious attention of steam engineers. W.

BOOK NOTICES.

Distribution de l'Energie par Courants Polyphasés. Par J. Rodet, Ingenieur des Arts et Manufactures. Paris: Gauthier-Villars. 1898.

[Distribution of Energy by Polyphased Currents. By J. Rodet, Engineer of Arts and Manufactures. Paris: Gauthier-Villars. 1898. 8 vo., pp. 338, with illustrations. Price 8 francs.]

This work treats of all branches of the subject of polyphased currents with satisfactory thoroughness.

The several chapter heads embrace the following themes: History, treating of the general principles involved in the production of two-phase, three-phase and polyphase currents, and the principles of construction of motors for currents of these types; line construction and the consideration of the phenomena occurring in distribution; transformation of polyphase currents; motors; meters; and finally, the description of the notable installations for the transmission and distribution of electrical energy by polyphase currents. W.

Kosten der Krafterzeügung. Tabellen ueber die Kosten der effectiven Pferdekraftstunde für Leistungen von 4-1000 P. S., vei Verwendeung von Dampf, Gas, Kraftgas, oder Petroleum als Betriebskraft. Aufgestellt von Chr. Eberle, Lehrer an der Kgl, Maschinenbauschule zū Duisburg. Halle a. S.: Verlag von Wilhelm Knapp. 1898.

[*Power Costs.* Tables of cost per effective horse-power hour, for duties ranging from 4-1000 horse-power hour, with the use of steam, gas, producer gas or petroleum as the source of power. By Chr. Eberle, Instructor in the School of Machine Construction in Duisburg. Halle a. S. Wm. Knapp, 1898.]

This publication is a valuable compilation, made from German data, of the comparative costs of the several typical forms of power generators included in the class of heat engines, and cannot fail to prove extremely useful for reference by engineers. The tables embrace the performance of stationary steam engines with saturated and super-heated steam, locomotive engines, gas motors, producer-gas installations, and petroleum motors.

The tables are arranged to exhibit in order the costs of installation, yearly costs of operation, and costs per effective horse-power hour. W.

The Gas Engineer's Pocket-Book. Comprising tables, notes and memoranda relating to the manufacture, distribution and use of coal gas, and the construction of gas works. By Henry O'Connor, Assoc. Mem. Inst. C.E., etc. New York: D. Van Nostrand Company. 1898. 8vo., pp. 438. Price, $3.75.

The author has collected in this volume and arranged in practicable form for reference a great amount of information which the gas engineer will find admirably suited for his everyday use. The data and tables were collected by the author during a series of years for use in his practice as a gas engineer, and feeling, from his personal experience, the need of a work of this character, he has used the material as the basis for this pocket-book.

The examination of its contents, which we have been enabled to make, has given us a favorable impression of its comprehensiveness and thoroughness, and it can be recommended to the gas engineering fraternity as a valuable addition to the technical literature of gas manufacture. W.

Encyclopédie Scientifique des Aide-Mémoire. Paris: Gauthier-Villars et Fils. Masson et Cie. 1898.

The following additional volumes of this capital series of technical handbooks have been issued since our last notice:

Dariès (*G.*), Conducteur au service des Eaux de Paris, etc. Calcul des Conduit d'Eaux.

Laurent (*H.*), Examinateur d'admission à l'Ecole Polytechnique, membre de l'Institut des Actuaires français. Théorie des opèrations financières.

Aries (*E*), Chef de bataillon du Génie. Thermodynamique des systèmes homogènes.

Minet (*Adolphe*), Directeur du journal *l'Électrochimie.* Les Théories de l'Electrolyse.

Minet (*Adolphe*), Ingénieur, Directeur du journal *l'Électrochimie.* l'Electrométallurgie. Voie humide et voie sèche.

Dufour (*Albert*), Ingénieur civil. Etude d'un tracé de chemin de fer.

Bourlet (*C.*), Docteur ès Sciences, Professeur au Lycée Saint-Louis et à l'Ecole des Beaux-Arts, Membre du Comité technique du Touring-Club de France. Nouveau Traité des Bicycles et Bicyclettes. 2e edition. IIe Partie: Le Travail.

Laurent (*P.*), Ingénieur aux Usines Schneider et Cie. Polygone du Hoc. Déculassement des bouches à feu.

Miron (*François*), Licencié ès Sciences physiques, Ingénieur civil. Les Huiles minérales de pétrole, schiste, lignite.

Elements of the Mathematical Theory of Electricity and Magnetism. By J. J. Thomson, M.A., F.R.S., etc. Cambridge: University Press. 1895. 8vo., pp. 510. Price, $2.60.

The author has presented the fundamental principles of the mathematical theory of electricity and magnetism, and their more important applications in as simple a manner as the subject is capable of being treated. His work has already become well and favorably known to students, for whom it has been specially prepared. W.

The Discharge of Electricity through Gases. By J. J. Thomson, Professor in the University of Cambridge. (With diagrams.) New York: Charles Scribner's Sons. 1898. 8vo, pp. 203. Price, $1.

In this volume the author has collected the substance of four lectures on the discharge of electricity through gases, given at the University of Princeton, N. J., in October, 1896, in commemoration of the sesquicentennial of the University.

The subject is treated under three general heads, viz.: The consideration of the phenomena of the electrical discharges through gases in general, followed by the study of photo-electric effects, and the phenomena and effects of cathode rays. W.

Notes et Formules de l'Ingénieur, du Constructeur-Mécanicien, du Metallurgiste et de l'Electricien. Par un Comité d'Ingénieurs, sous la direction du L. A. Barré et Ch. Vigreux, etc. II^e^ édition, revise, corrigée et considerablement augmentée, contenant près de 1,000 figures, suivée d'un vocabulaire technique en Français, Anglais, Allemand. Paris: E. Bernard et Cie. 1898. 8vo., pp. 1312.

The volume above named, one of the best and most favorably known reference books for engineers—civil, mechanical metallurgical and electrical—in the French language. It is more comprehensive, in fact, than anything of the kind of which we have knowledge in English. Its utility is fairly well indicated by the fact the present edition is the eleventh. It is capitally printed, illustrated, and indexed. The polyglot vocabulary at the end of the volume is a substantial addition to its value. W.

Jahrbuch der Elektrochemie. Berichte über die Fortschritte des Jahres 1897. Unter Mitwirkung der Herrn Prof. Dr. Elbs, Giessen; Prof. Dr. F. W. Küster, Breslau; nur Dr. H. Danneel, Göttingen. Herausgegeben von Dr. W. Nernst und Dr. H. Borchers. IV Jahrgarg. Halle a. S. Verlag von Wm. Knapp. 1898.

The year-book of Nernst and Borchers has come to be recognized as the only authoritative collation of the progress of electro-chemistry from year to year. It fills an indispensable need for experts and students of this important and constantly growing branch of applied electricity. The present volume, though somewhat belated, will be found to have gained in thoroughness. W.

Lighting by Acetylene: Generators, burners, and electric furnaces. By Wm. E. Gibbs, M.E. New York: D. Van Nostraud Co., 1898. 12mo., pp. 141. Price, $1.50.

The general interest in the application of acetylene for lighting will doubtless give to this work a wide circulation. The author diplomatically evades committing himself on the subject of the original invention of commercial acetylene. His descriptions of electric furnaces, acetylene generators, etc., will be found quite valuable by those interested in the general subject. A list of U. S. Patents, bearing on the subject, and the requirements of the New York Board of Fire Underwriters, which he publishes, add to the value of the book. W.

Alkaloidal Estimation. A bibliographical index of chemical research prepared from original chemical literature for the Committee on Revision. By Paul I. Murrill, under the direction of Albert B. Prescott. Published by the Committee on Revision. Ann Arbor, Mich. 1898.

This volume of fifty-eight pages octavo comprises a descriptive bibliographical index to the literature of the estimation of alkaloids, prepared from current scientific periodicals, by the Committee of Revision and Publication of the Pharmacopœia of the U. S. of America, 1890–1900. W.

Special Report on the Beet Sugar Industry in the United States. Washington, D. C. Government Printing Office. 1898. 8vo., pp. 240.

The above-named volume contains the detailed report of the experts of the U. S. Department of Agriculture on the subject of the beet sugar industry, which has been greatly stimulated in recent years by the intelligently directed efforts of the Department. W.

Sugar Beet Seed. A work for farmers, seedsmen and chemists, etc. By Lewis S Ware, M.E., etc. Profusely illustrated. New York: Orange Judd Company (Philadelphia Book Company). 1898. Price, $2.

The work above named contains the results of the author's extended study of the subject during many years which he has devoted to the beet sugar industry. The author's mission has been, and is, to promote the establishment of this industry on a successful commercial basis in the United States, and at considerable personal sacrifice of time and money he has maintained, for nearly twenty years, a journal—the *Sugar Beet*—devoted to the diffusion of knowledge on this important subject. At the present time, it appears as if he were approaching the realization of his aspirations. His thorough familiarity with every phase of the beet sugar industry—in which he is an acknowledged authority—renders any commendation of the present volumes a work of supererogation. W.

Methods for the Analysis of Ores, Pig Iron and Steel in use at the laboratories of iron and steel works in the region about Pittsburgh, Pa. Together with an appendix containing various special methods of analysis of ores and furnace products Contributed by the chemists in charge, and edited by a Committee of the Chemical Section, Engineers' Society of Western Pennsylvania. Easton, Pa. Chemical Publishing Company. 1898. Price, cloth, $1; paper, 75 cents.

The methods described in this work represent the general practice which is followed in the principal iron and steel works in Pittsburgh and the region adjacent thereto. The committee named to edit the replies received in response to the circular issued by the Chemical Section of the Engineers' Society of Western Pennsylvania, was composed of Prof. F. C. Phillips, of the Western University of Pennsylvania; A. G. McKenna, Duquesne Steel Works, Dusquesne, Pa., and E. S. Johnson, of Park Bros. & Co., Pittsburgh. The methods of some sixteen iron and steel works are included in the volume. There is an appendix, giving analytical methods for certain special examinations occasionally of importance to the iron and steel chemist. W.

Theory and Calculation of Cantilever Bridges. By R. M. Wilcox, Ph.B., Instructor in Civil Engineering in Lehigh University. New York: D. Van Nostrand Company. 1898. 16mo., pp. 108. Price, 50 cents.

This volume replaces the original No. 25 of the Van Nostrand Science Series, on the "Theory and Calculation of Continuous Bridges," by Prof. Mansfield Merriman, published in 1875. It presents concisely the theory and methods of calculating the stresses in the trusses of cantilever bridges.

W.

The Tutorial Statics. By Wm. Briggs, M.A., F.R.A.S., etc., and G. H. Bryan, Sc.D., F.R.S., etc. London: W. B. Clive. New York: Hinds & Noble, N.D. 8vo., pp. 360. Price, $1.50.

This addition to the publications of the University Correspondence College press, is distinguished by the same thoroughness which has gained for its companion volumes a wide popularity.

W.

Franklin Institute.

[*Proceedings of the stated meeting held Wednesday, October 19, 1898.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, October 19, 1898.

MR. JOHN BIRKINBINE, President, in the chair.

Present, 116 members and visitors.

Additions to membership since last month, 9.

The principal paper of the evening was read by Mr. Edward H. Johnson, of New York, on the "Johnson-Lundell Surface-Contact System of Electric Railways."

In this system, the feeder wire runs in a conduit under the street and is connected to the car through buttons, or small steel nuts, which project about half an inch above the pavement, between the tracks. These buttons are not connected with the feeder wire except while the car is passing over them, and, therefore, cannot do any injury at any time to man or beast.

There are two lines, or rows, of these buttons, parallel with the rails. As the car comes along, two shoes, about 12 feet long, carried by the car just above the ground, press against these buttons. A magnet on the car, operated by a small storage battery, lifts a switch, which is under the street, which closes the circuit with the feeder wire, and the current passes through the buttons to the shoe, through the motor and back through the other shoe to the other side of the circuit. The magnet of the switch on the section just

beyond the car is energized just as the car reaches the section, and the section which the car is just leaving returns to its normal condition. In cases where there is, for any reason, a disconnection in the circuit, there is power enough in the battery to move the car over the break. The car is lighted from the battery circuit by low voltage lamps, and the battery is kept charged by the current from the feeder wire as it runs over the track.

This system is new and has been operated only experimentally on a line 3,000 feet long on Thirty-fourth Street, New York, where it has had eight months' service, said to have been satisfactory.

Further details are reserved for future publication.

Mr. Edward J. Moore presented a brief description of an improved form of marine boiler, of his invention. The apparatus is of the water-tube type, with two furnaces, and an economizer or feed-water heater, so disposed on top of the latter as to effectively utilize the heat of the ascending combustion products. The inventor makes the claim that his construction presents a much greater amount of heating surface for the same dimensions than is afforded in other boilers of this class, and specified numerous other advantageous features.

Prof. Joseph W. Richards, of Lehigh University, Bethlehem, by special invitation, gave an informal address, dealing with a number of items of scientific and technical interest which had come under his observation during a recent European visit. He referred, among other things, to the use of petroleum for fuel on Russian railways and steamboats; electric tramways in Germany, the sodium works at Oldbury, near Birmingham, England; the use of sheet aluminum in lithography in Germany, as a substitute for lithographic stone, and the recent pronounced development of the manufacture of aluminum in England.

Mr. James Christie, chairman *pro tem.*, expressed the thanks of the meeting to the speaker for his extremely interesting remarks.

Mr. Ernest M. White presented some remarks, with illustrations supplementing his communication at the stated meeting of September 21, on the subject of "Chimneys for Incandescent Gas Lamps."

Adjourned. WM. H. WAHL, *Secretary.*

COMMITTEE ON SCIENCE AND THE ARTS.

[*Abstract of the proceedings of the stated meeting held Wednesday, September 7, 1898.*]

PROF. L. F. RONDINELLA in the Chair.

The following report was adopted:

Automatic Air-Brake Mechanism—G. F. Jeffries, Reading, Pa.

ABSTRACT.—This invention consists of an arrangement whereby the brakes may be applied to a railway train from the roadbed, independent of the engine

driver. This is accomplished by a valve placed in front of the forward wheels of the locomotive. This valve has a long lever or handle located in such position as to come in contact with a trip, about 1½ inches above the rail, which can be placed in position by the brakeman, or raised and lowered by means of levers from a switch or signal, to prevent collisions caused by the oversight or neglect of the engine driver to observe the usual signals.

The Committee finds that while the device would perform its intended function, and commends the inventor for the conception of a life-and-property-saving invention, the benefits to be derived from its use are not sufficient to offset a number of detrimental and impracticable features it possesses. [*Sub-Committee.*—Jacob Y. McConnell, Chairman; C. H. Downs, Henry F. Colvin, Calvin G. Turner, Henry Harrison Suplee.]

Smoke Nuisance Ordinance.—An amended draft of this document was presented, and, after some discussion, was adopted and ordered to be transmitted to the Board of Managers.

The following report passed first reading:

Pneumatic Dispatch Tube Apparatus.—B. C. Batcheller, Philadelphia. Referred by the Institute.

A motion to reconsider the Committee's Report on the Heintz Steam Trap was adopted.

W.

SECTIONS.

CHEMICAL SECTION.—Stated Meeting, October 18, 1898. President, Dr. Lee K. Frankel, in the chair.

Mr. Charles A. Hexamer read a paper on "Chemical Fire Extinguishers," which was freely discussed.

A communication from Mr. Wilfred Skaife, Montreal, Canada, on "The Field for Chemical Improvement in the Manufacture of Sugar," was read by title, and referred for publication.

An artificial stone, known under the name of "Reconstructed Granite," was exhibited and commented on by Dr. Wahl, Mr. Hexamer and Dr. Day.

W.

MINING AND METALLURGICAL SECTION.—*Stated Meeting*, October 12, 1898, President A. E. Outerbridge, Jr., in the chair.

Mr. Wm. Griffith, Mining Engineer, Scranton, Pa., read a paper on "Anthracite Coal in Peru." Freely discussed and referred for publication. The thanks of the meeting were voted to the speaker. W.